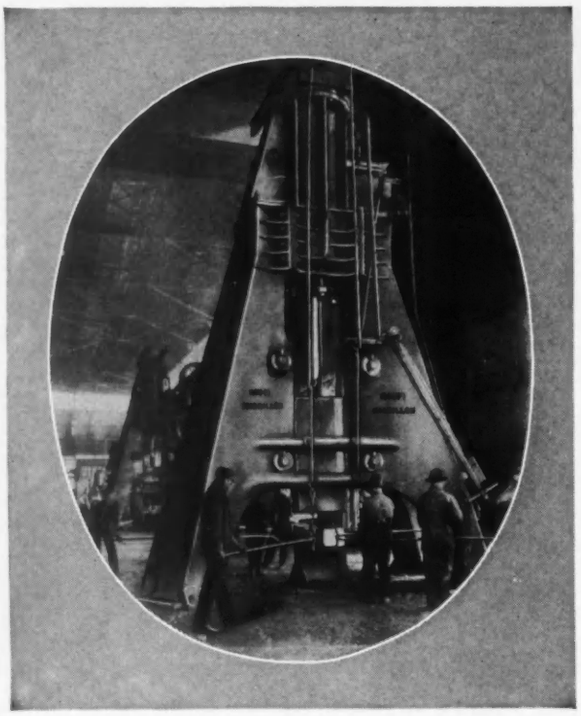
JANUARY 1938

Product Engineering

McGRAW-HILL PUBLISHING CO., INC.

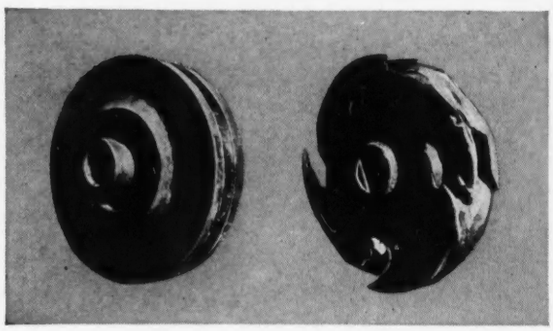
PROFITS *leak through many a loophole*



NICKEL CAN EASILY PLUG

MACHINERY repairs and replacements often run higher than you anticipate—often throw you for a *loss* when you are expecting to make a *gain*. Frequently, time lost when machines are out of action, may be far more costly than the expense of making the repairs themselves. But when equipment is fortified at vulnerable points with strong, tough alloys of Nickel, service records often stretch for astonishingly long periods. At left, a forging hammer illustrates the point. Located in a large Ohio Valley plant, it has bushings of Nickel alloy iron, produced by the Continental Roll and Steel Foundry Company. Because of wear in the bore it was recently decided to replace these bushings. When the records were looked up it was found that they had served for *ten years*. Bushings of the same composition had also served another hammer in the same plant for *twelve years*. Hence, when the new order was placed the same producer was asked to duplicate the original composition of Nickel cast iron. A record, demonstrating the need for keeping a record.

BEFORE and after — what happens to plain white cast iron impellers operating in pumps handling highly abrasive material consisting of 73% solid matter. Failure at the end of 551 hours was the average record of eight of these impellers. Yet, operating under identical service conditions, six NI-HARD* Nickel-chromium cast iron impellers demonstrated an average life of 1319 hours, a ratio of 2.39 to 1 in favor of NI-HARD. These results were obtained from records compiled at the Copper Cliff, Ontario, operations of The International Nickel Co., Inc.



UNDER the high-speed multiple drill pictured at the left is a compressor cylinder destined for use in refrigeration apparatus made by the York (Pa.) Ice Machinery Corporation. Among the requirements that must be met by a metal for this service are pressure-tightness, high wear-resistance and ease of machinability. All of these are supplied by Nickel cast iron, hence this is the material used by York for cylinders, top heads, pistons, crankcases and bearing heads. The company states that these parts in which Nickel is used *have never yet required replacing because of wear*. We invite consultation on the use of the alloys of Nickel in your equipment.

* NI-HARD—Reg. U. S. Pat. Off. by The International Nickel Co.— Canadian Patent No. 281,986.

NICKEL CAST IRONS

THE INTERNATIONAL NICKEL COMPANY, INC., NEW YORK, N. Y.

✦ PRODUCT ENGINEERING

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *EDITOR*

McGRAW-HILL PUBLISHING CO., INC. JANUARY 1938 VOLUME NINE, NUMBER ONE

Your Product and Its Sales Curve

BE IT OF A living creature, the population of a city, or the sales of an industry, the curve of growth follows the same general course. After a slow beginning comes a period of rapid increase which sooner or later tapers off. Eventually the growth curve becomes a more or less horizontal line. In the case of markets we call it the saturation level.

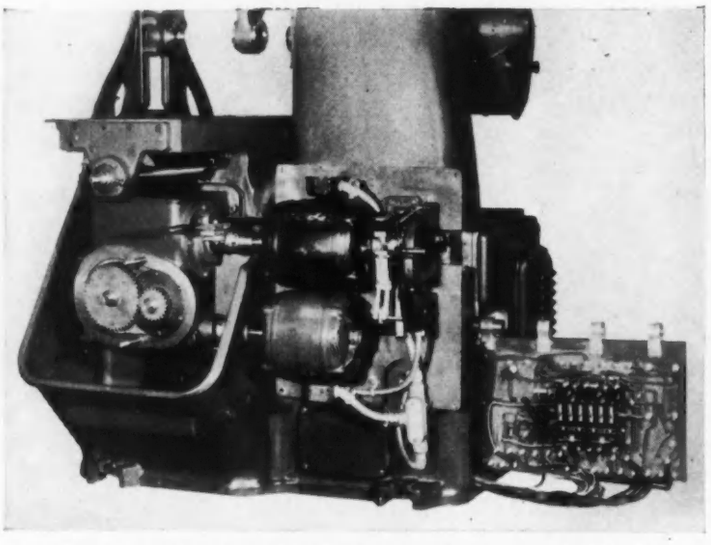
During the past two decades a great many industries have been living in the second stage of their growth curve. Automobiles, airplanes, radios, electric refrigeration and oil burners are common examples. Production and construction machinery have also passed through the second stage. In each case a great demand was created as soon as the service value of the new machine or product was generally recognized. The manufacturer had to speed up production to satisfy the demand. Selling was easy. It was a mere matter of order taking. As expressed by Colonel Chevalier, "The manufacturers were pumping into a vacuum."

The second stage of growth is a gala time for the industry. No particular attention need be paid to the design of the product. "She takes you there and brings you back" was quality enough for the early automobile. And salesmen of the product have a glorious time, their only worry being that the manufacturer cannot fill their orders fast enough. But for most products that time is now past. We may reminisce about it, but we would do better to face the fact and do something.

For most products today's market is primarily one of replacement. Replacements are made either because a machine is worn out or is obsolete. But machines wear out too slowly to support a reasonable market and thereby hangs the tale. Today's markets must be maintained by obsoleting existing products and equipment. This can be done by improved designs that possess new service values or provide greater owner satisfaction. These two are the only reasons that can persuade the prospect to become a customer.

Ball bearings never sold a bicycle but the easier pedaling of the ball bearing bicycles sold millions of them. The finest design of built-in pump never sold a washing machine, but the fact that it eliminated the drudgery of emptying the tub with a bucket created a new market.

Thus it is that two highly important factors are now in the forefront. First, products that have reached the saturation level must be redesigned to obsolete existing designs. And secondly, to obsolete an existing design the new model must possess new service values and offer greater owner satisfaction sufficiently impressive to cause the prospect to buy. Therein lies the designer's opportunity and the country's prosperity.



Rapid table traverse of Sundstrand Electromil is powered with a torque motor which operates intermittently. The motor is equipped with a solenoid operated brake for quick stopping of the rapid traverse

TORQUE MOTOR DRIVES

For Stalled and High Inertia Loads

Many possible characteristics that can be built into torque motors are utilized in machines to accelerate large masses quickly or to exert full load torque while standing still

MECHANISMS, which are required to have motion up to a certain point and then while stalled are also required to exert mechanical pressure on other parts of machinery, present many difficult problems in the design of equipment. To operate devices of this kind the ordinary type of motor is usually unsuitable because it cannot pull up and stand under load. In this respect the motor resembles an internal combustion engine in that torque can only be exerted while either machine is running. In electrical motors the reason for this is that the revolving armature or rotor generates a back-voltage which opposes the supply current and permits only enough current to flow to make up for the load. If completely stalled, therefore, no back-voltage is generated and the current rises to an excessive amount which quickly burns out the motor windings unless the fuse blows promptly.

When stalled at the end of a cycle, torque motors exert enough opposing effect to the supply voltage to hold the current down to that of full load and thus exert full load torque which by mechanical means is translated into the required motion.

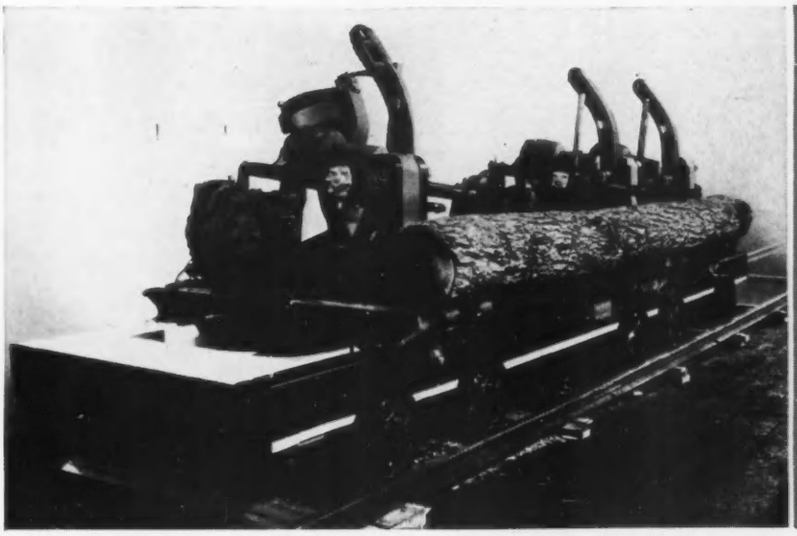
Torque motors are special and although standardized in various sizes are usually built to fill the specific operating requirements of a machine. They are designed with the proper working characteristics and are built like any standard motor. Torque motors differ from standard motors in that they never reach so called full load speed, because the mechanisms they operate reach the end of a working cycle before sufficient time elapses for the motor to come up to speed. The primary purpose of torque motors is to deliver a certain torque and to maintain that torque even after coming to a standstill so long as the windings are kept energized.

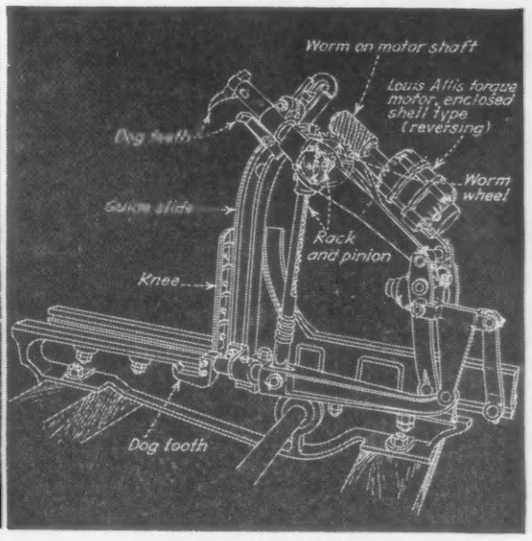
Characteristics Obtainable

Torque motors can be wound for either alternating or direct current. The various ratings are based upon the particular torque required, the length of time the motor is to be kept connected to the circuit and also the frequency of operation during an hour. How long the motor can remain stalled depends on its stalling rating. Some ratings can be held for only five or ten minutes during each hour, others will withstand such treatment for many hours at a time.

It is frequently convenient for users of torque motor equipment to have some idea of the power required per ounce-foot in the rotor. For the polyphase induction torque motors, the power input to the rotor is almost completely independent of the design proportions, except when cogging, friction or other defects are present. In Table I are given the rotor input watts required per ounce-foot of torque on the motor shaft for different frequencies and pole numbers.

Motor input required is several times the number of watts given in Table I because of iron and primary copper losses. The figures show that for a given supply frequency many poles are better than few poles. Unfortunately, the magnetizing current, primary copper losses and construction difficulties rise more rapidly than the rotor copper loss falls off, so that there is a best number of poles quite apart from the question of slow motion versus fast motion. Six, eight and twelve poles are frequently met with. Some actual figures from prac-





Power dogging mechanism on Prescott sawmill carriage is driven by a reversing shell type torque motor which has a top speed of 1,600 r.p.m. and is rated at 45 lb.-ft. torque. Motors operate 15 to 20 times per minute and accelerate a heavy mass of machinery quickly. When the dogging cycle is completed the motors plug.

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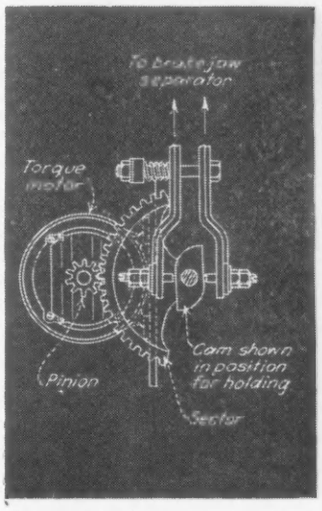
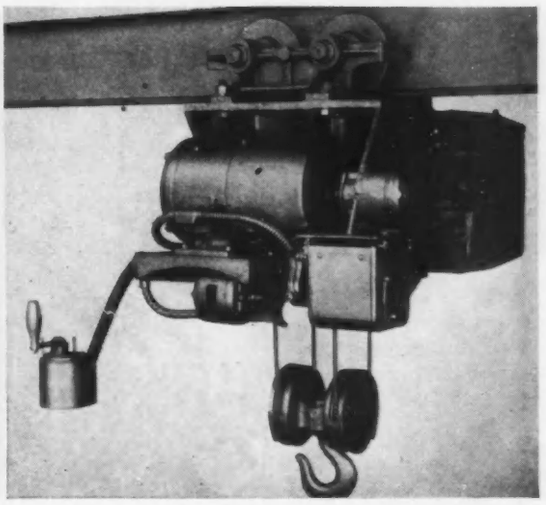
tice indicate supply inputs of from 2 to 4 times the rotor figures.

The employment of torque motors is becoming widespread not only because they have the ability to concentrate a specified amount of torque in the smallest possible dimension, but also because many operations can be accomplished in less complicated, less costly and better appearing methods. The arrangement is in line with the present built-in and pushbutton controlled style of operation.

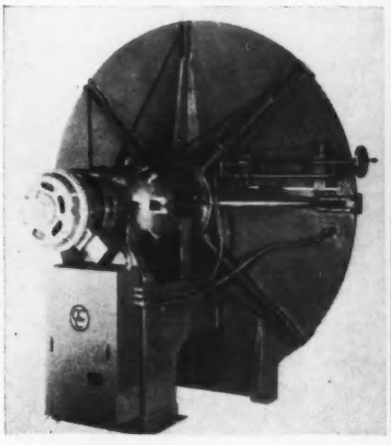
The possible characteristics of high torque motors make their use desirable for supplying energy to mechanical arrangements for clamping, unclamping, locking, unlocking, elevating, lowering, traversing, counterweighting, feeding, indexing, inching and stalling, also for operating clutches and valves.

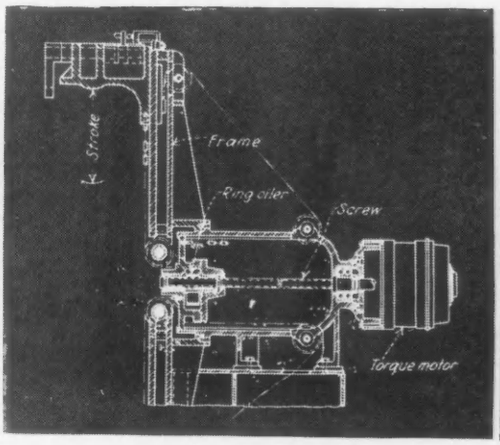
A few of the many ways that this type of electrical motor power is applied or built into machines and equipment are

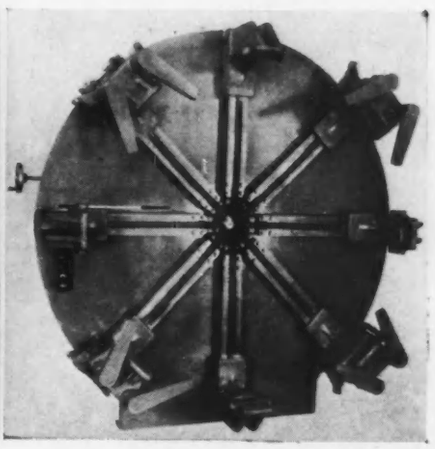




Geared to the toothed sector is a torque motor which is energized by operation of the controller on a Robbins & Myers' hoist. When lifting or lowering a load this toothed sector turns a cam which by means of a linkage system separates a pair of brake jaws embracing the brake drum on the main motor shaft.





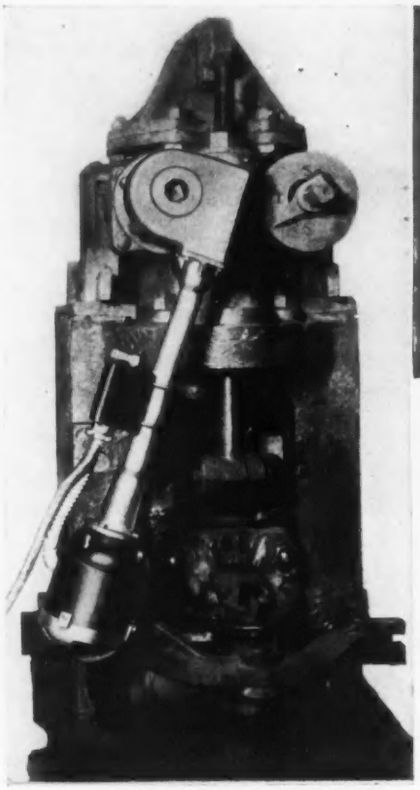


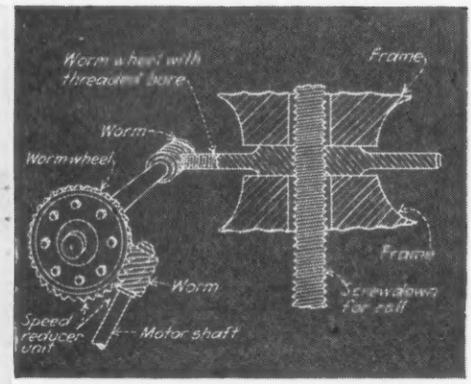
Tractor tires after the vulcanizing operation are clamped in this machine built by the National Rubber Machinery Company. While clamped the beads are spread and the air bag around which the tire was vulcanized is extracted. A torque motor turns a screw in a nut in the sliding head to which chains are attached for operating clamping blocks.

illustrated in this article. Many safety and fire-control protection devices employ torque motors. For elevator gate-closing mechanisms mentioned in the article "Torque Motors and Their Applications" which appeared in April, 1937, P.E. Vol. 8, No. 4, the comparatively long lineal travel and the need for reversible motion render the torque motor preferable to the solenoid. A number of freight and passenger elevator makers have adopted these motors as standard equipment. For remote control of steam and fire-protection lines, either solenoids or torque motors can be built into the valves. However, a solenoid operated valve must be of the needle or plunger type, whereas the more powerful and positive rotary screw valve can be operated with a torque motor. Operation of automatic switch sequence control, as in steel mill motor work, brake operation on cranes and hoists, are less noisy with motor-drive.

On machine tools high starting torque a.c. motors are selected for operating rapid traverses because they provide the torque necessary to break free the high inertia loads carried on the ways, and because of their inherent simplicity of construction and control little maintenance is required.

These and many other intermittent operations are found in industrial machines such as radial drills, milling machines, planers, boring mills, broaching machines, shapers and others too numerous to mention. Generally, good applications for high torque motors are machines having motions of relatively short or intermittent periods of operation.



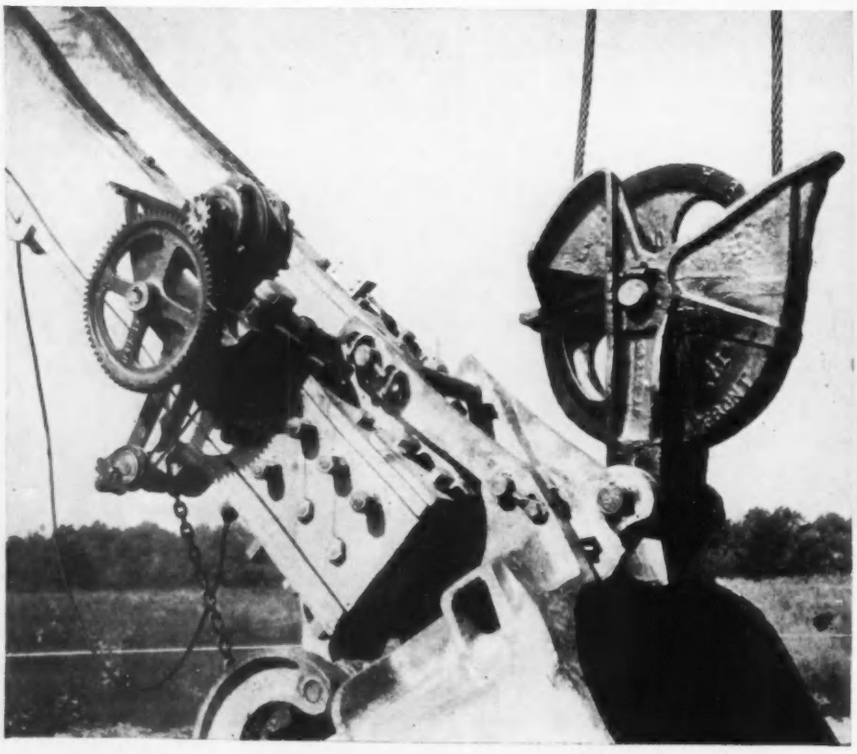


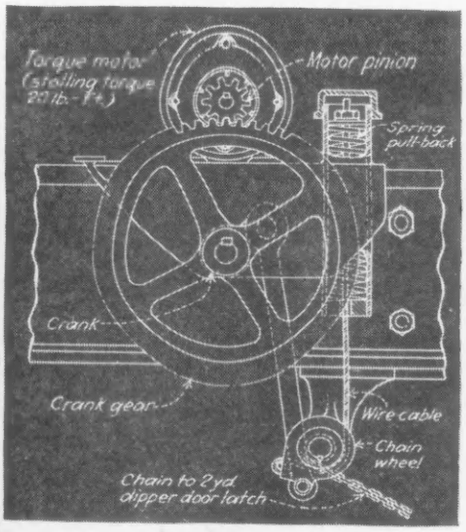
Motor driven socket wrench is employed on rolling mill stand for operating screw-down mechanism which adjusts distance between rolls. The aluminum torque-tube contains a shaft which is direct connected to an Ohio torque motor at one end and to a worm-gear speed reducer at the other end. The worm-gear in the speed reducer has a central socket hole which is fitted over the squared end of a shaft that is geared to an adjusting screw. Connecting plug receptacle and a reversing switch are mounted on the torque-tube for convenience in operating unit.

Rotor Input in Watts per Ounce-Foot of Torque in Polyphase Induction Motors

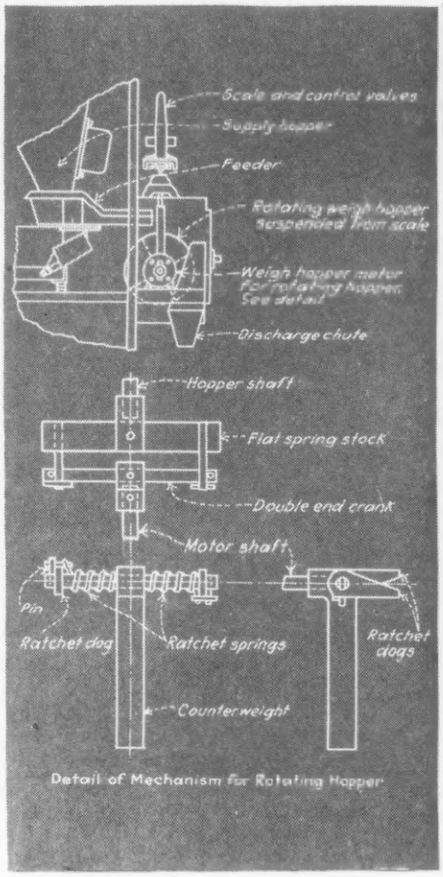
Cycles	Number of Poles 2	4	6	8	10	12
25	13.3	6 66	4.46	3.33	2.67	2.21
30	16.0	8.00	5.33	4.00	3 20	2.65
40	21.3	10.70	7.14	5.71	4.56	3.78
50	26.7	13.30	8.90	6.66	5.33	4.41
60	32.0	16.00	10.70	8.00	6.40	5.30

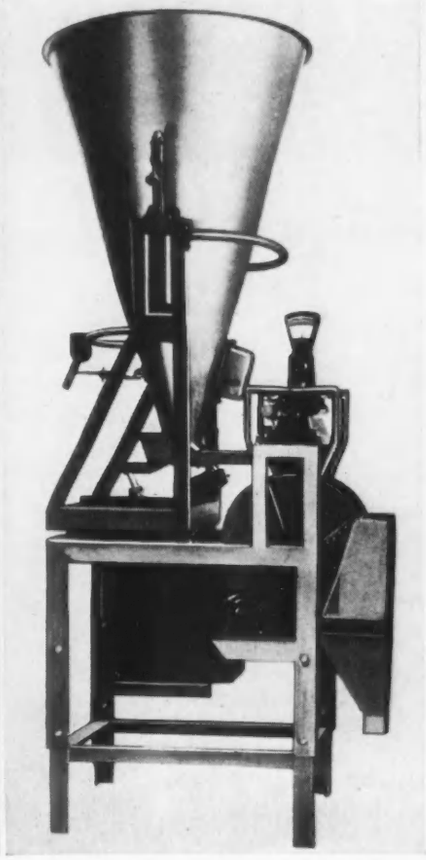
Contributed by A. F. PUCHSTEIN, *Chief Engineer, Robbins & Myers, Inc.*





Dipper is tripped in a half revolution of crank gear when power is applied to motor on this Bucyrus-Erie machine. After tripping, when the dipper handle is lowered the door latch falls into place by gravity and the spring loaded cable pulls the crankpin to low position in readiness for next trip.





Hopper bucket is rotated with a torque motor in Syntron Batch Weighing Machine. Motor starts under the load of a counterweight and rotates about 60 deg. before the full load of the bucket is picked up, then rotates about 30 deg. farther before stalling for approximately a second. After current is cut off the counterweight returns the motor to its original position. The motor carries a crank having ratchet type dogs which engage a flat spring on bucket shaft. The motor when not energized must be entirely disconnected from the bucket.

ACKNOWLEDGMENT

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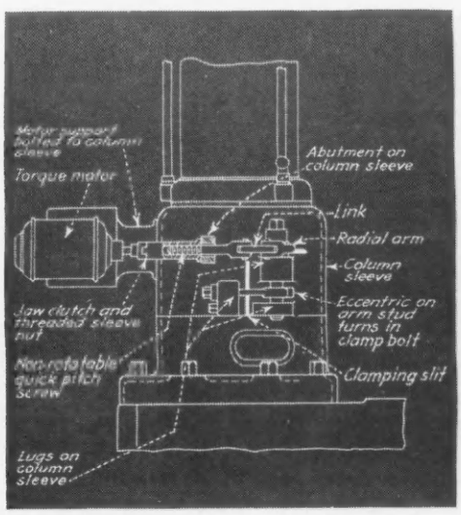
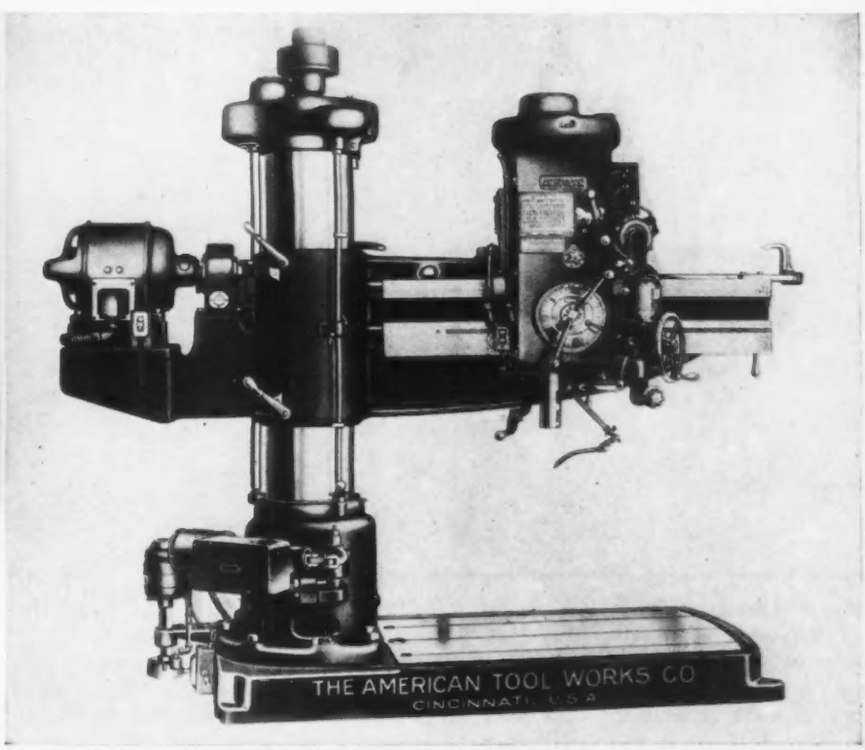
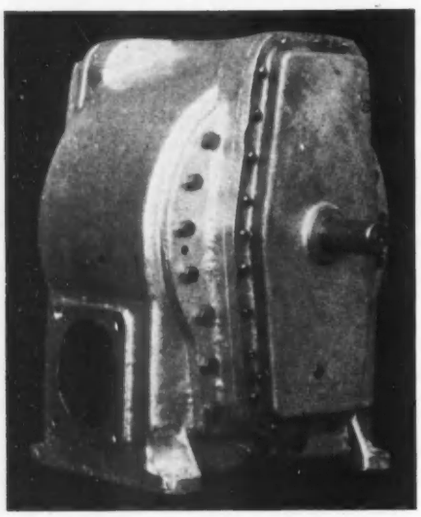


Clamping unit on American radial drill is bolted to the rear lower side of the column sleeve. A torque motor is connected by a jaw tooth coupling to a threaded sleeve which turns on a non-rotatable quick pitch screw. An eccentric section of a stub shaft actuates a clamping bolt against a lug abutment.



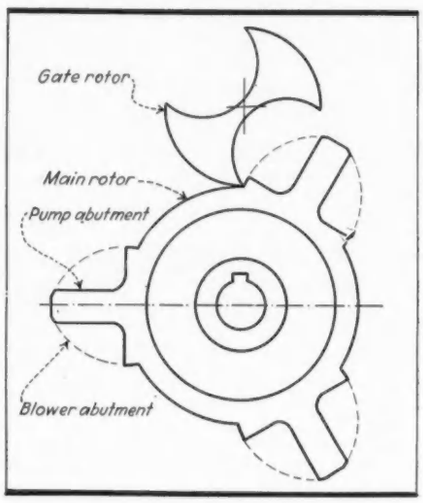
Modern Designs

Blower-Pump Design Affords Ease of Assembly and Disassembly

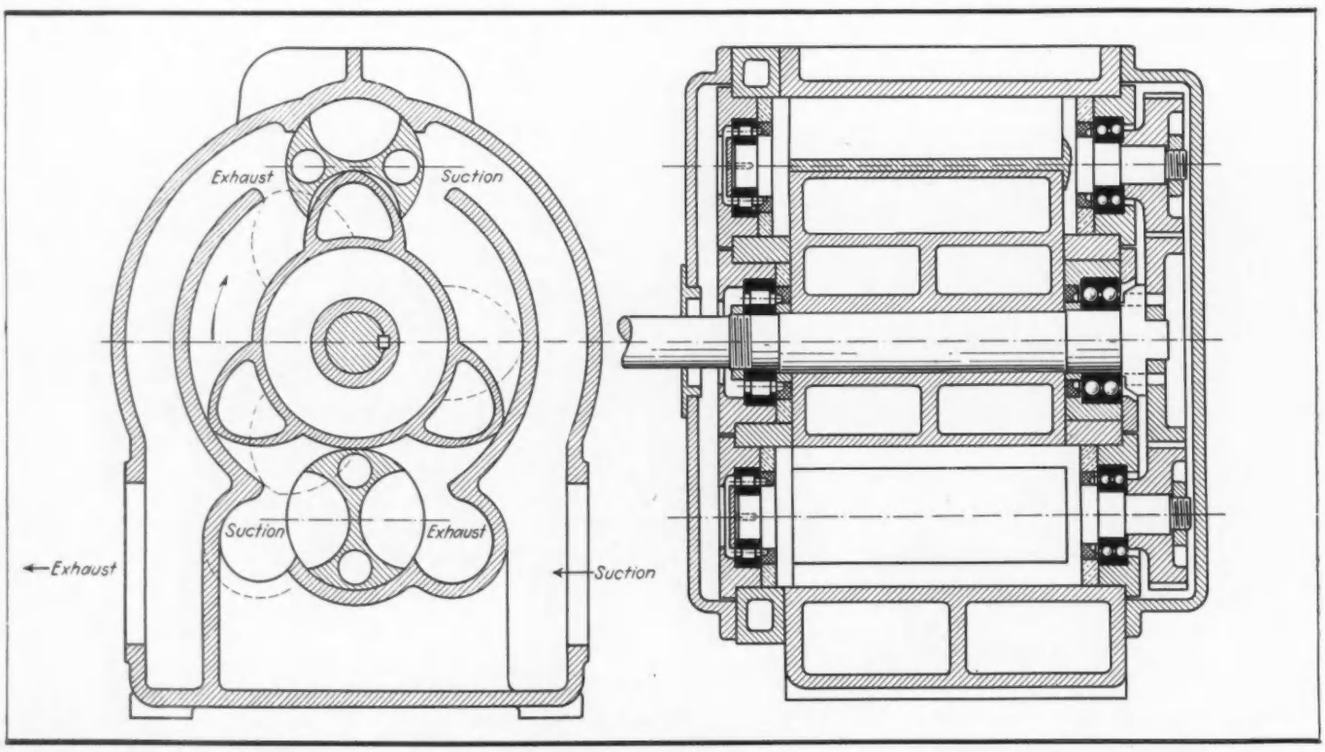


Blower-Pump Unit recently developed by Rotary Compressor-Blower Corporation. Case and case heads are aluminum.

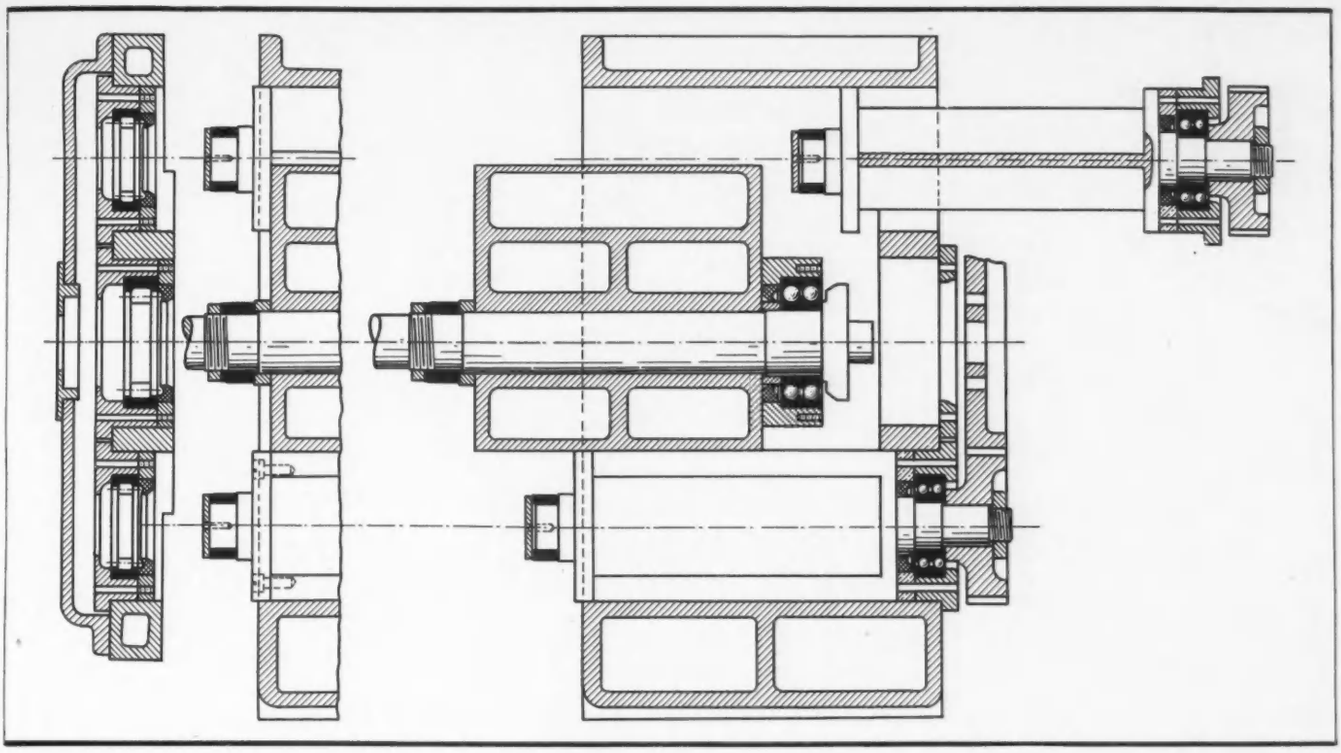
WITH ONLY SLIGHT design alterations, the Whitfield Uni-Flow Blower becomes a pump for oil and other liquids. Alterations consist mainly of change in shape of abutments on main rotor. Reason for change is that if blower were used as pump liquid would be trapped in the gate-rotor pockets, creating pressure and possibly causing leakage. However, whether produced as pump or blower, unit is so designed as to permit disassembly without use of bearing or gear pullers and without affecting adjustments.



Abutment Shape is changed from that shown by dotted lines to that shown by solid lines in converting blower to pump.



Blower Construction, with main-rotor abutments shown dotted to indicate a 30-deg. rotation. Steel timing gears synchronize gate rotors with main rotor. All work is done by main rotor and, since load on it is partially balanced, bearing load is light. There is no metal-to-metal contact between rotors and case. Medium speed machines, low to medium pressures, have cases and case heads of aluminum and rotors of bronze. For higher-speed and higher-pressure machines, cast-iron cases and case heads and forged-steel rotors are used. Also, in higher-speed units, gear teeth are heat-treated and ground, backlash being held to minimum. Garlock Klozures are used for seals.

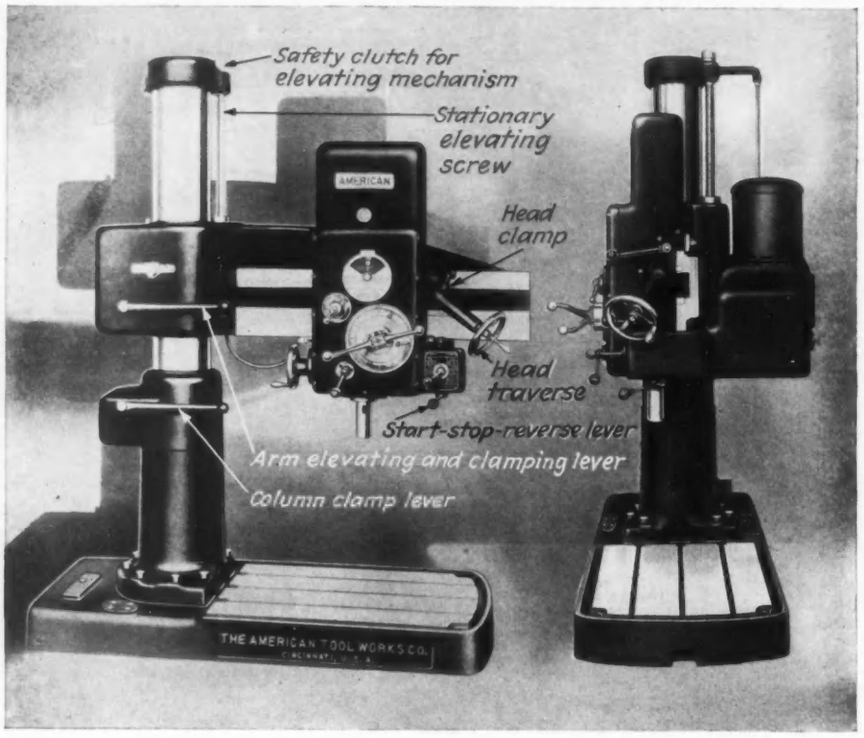


Partially Disassembled—The case end is removed, the lower gate rotor is in place, the main rotor is partially removed, and the upper gate rotor is almost completely removed. Bearing or gear pullers are not needed, all parts being designed for ease of assembly and disassembly. Moreover, disassembly does not affect adjustments.

Zinc Die-Castings and Stainless Steel for Moving Stairway

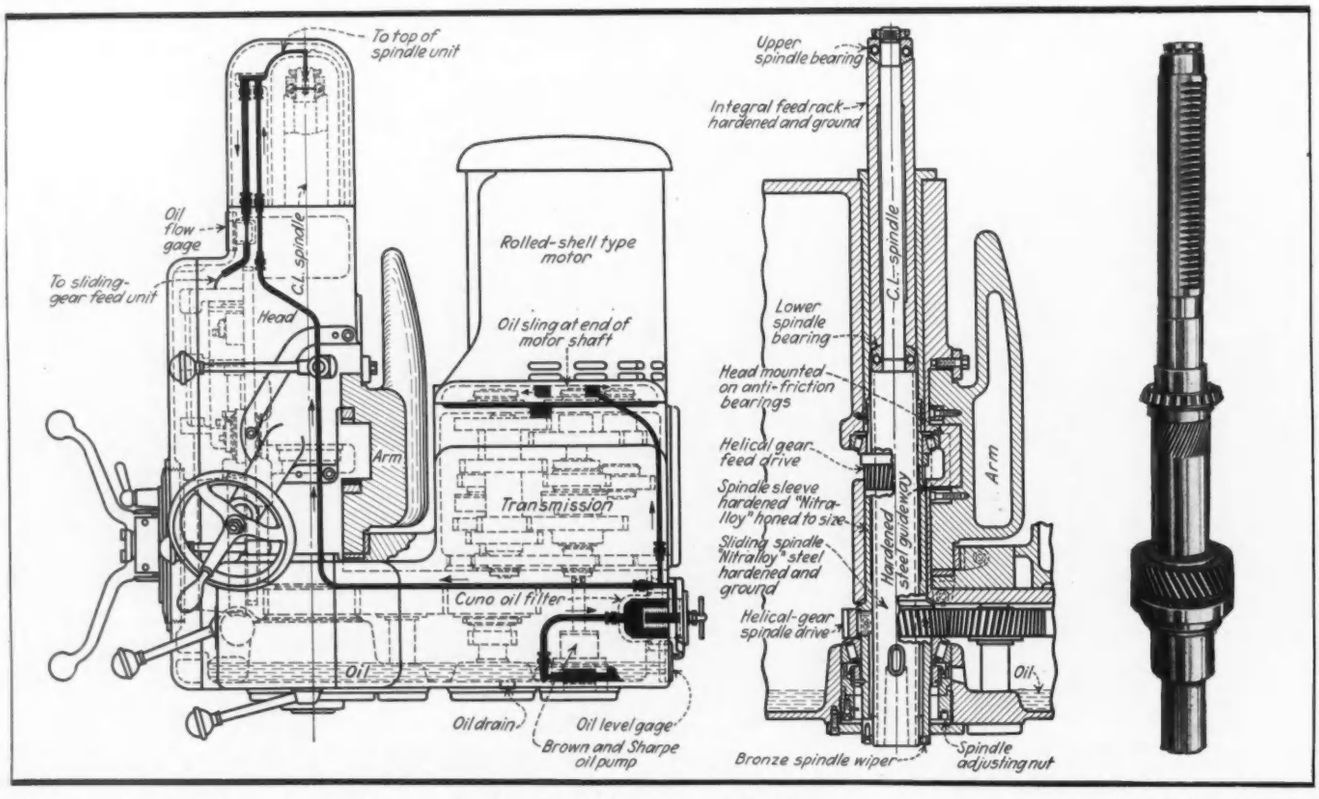
Modern Escalator Step has die-cast tread of zinc alloy, attractive riser of stainless steel. Former design, shown in assembly at right, employed hard-wood cleats which wore more rapidly. New tread, as used by Otis, has Brinell hardness of 71, No. 6 Zamak alloy being used. Castings are either 8½- or 12-in. wide, made in sections averaging about $\frac{1}{16}$-in. thick. Ribs are hollow. Holes for through-bolts are cored and, other than trimming of flash, no machining is required. Sprayed finish of black lacquer is applied and, when dry, is sanded off top face only, making each rib stand out brightly. Normal use in contact with soles of shoes keeps tread face bright.

Modern Designs—Gear-Units and Motor Inbuilt in 12-Speed Drill



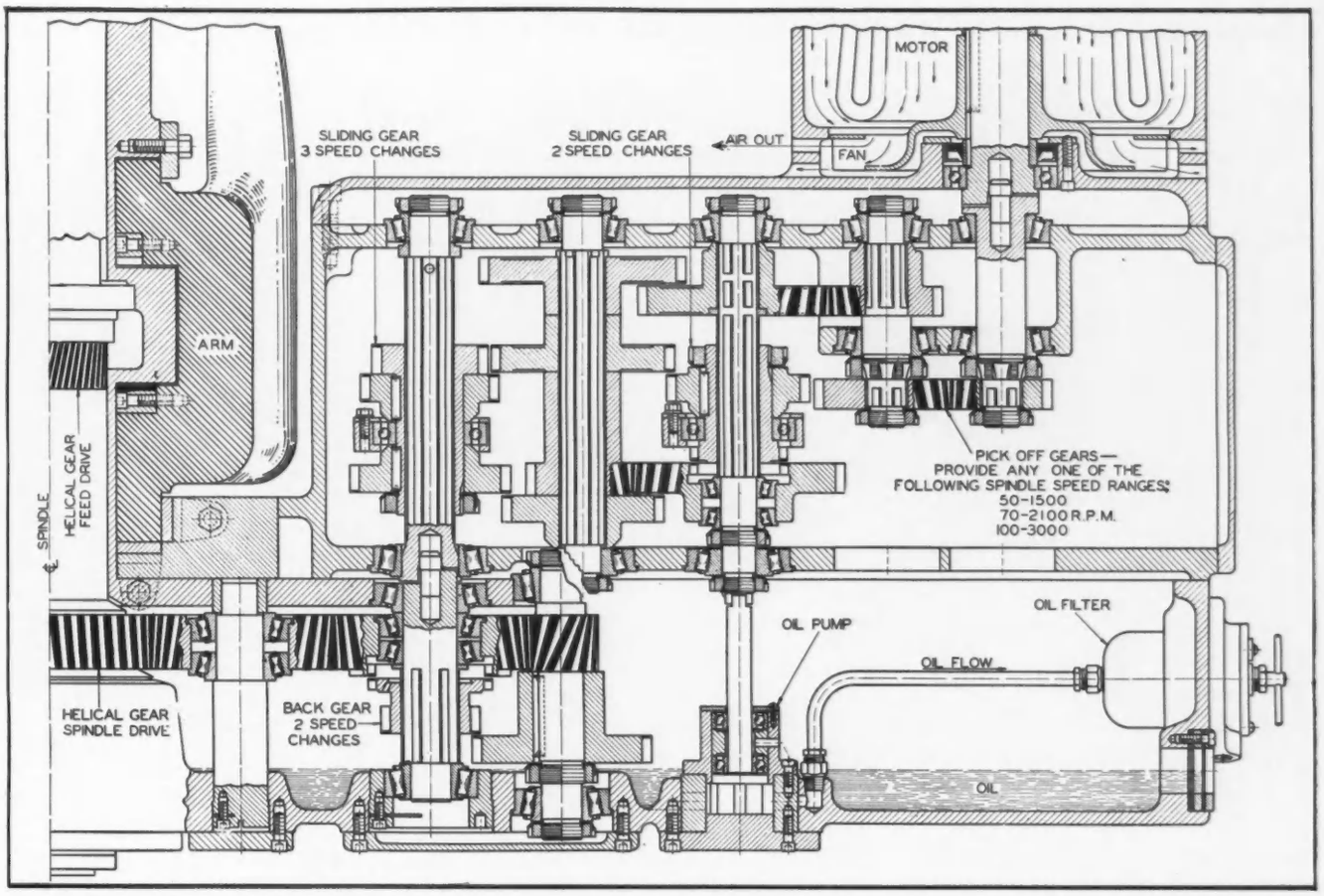
BOTH spindle speed-change transmission and sliding-gear unit that gives six rates of spindle feed are "designed-into" head of new Hole Wizard radial drill recently developed by American Tool Works. In addition, arm-elevating mechanism, together with its driving motor and control, is inbuilt.

Rolled-shell type motors contribute further to compactness of machine. Concentration of speed and feed gearing, as well as main-drive motor, in head permits centralization of controls for maximum operating convenience, without complicating design. Motor controls are magnetic type.



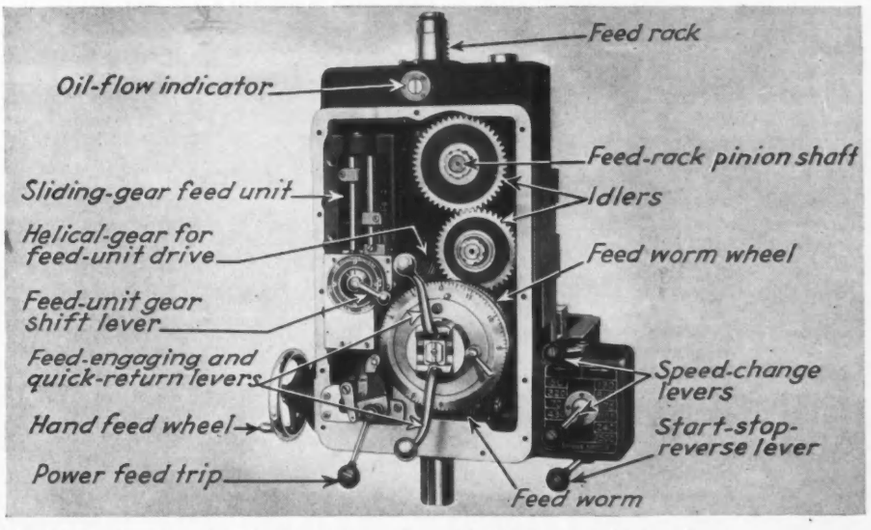
Head and Spindle Assemblies, showing compact arrangement of parts and circuit of lubrication system. For easy travel, head has two large anti-friction bearings (not shown), outer races of which roll on the hardened-steel guide in the arm. Drive motor is 5-hp., ball bearing, rolled-shell type, built into special frame and mounted directly on top of transmission case at rear of head.

Start-stop-reverse lever operates a double pilot control switch connected to the magnetic reversing switch for the main-drive motor. Braking and reversing are accomplished by "plugging" the motor. Spindle and spindle sleeve are of Nitralloy, the sleeve being mounted in Timken roller bearings adjustable for wear. Lower helical gear on sleeve drives spindle unit; upper one meshes with drive for the sliding gears.



Transmission-Assembly Diagram reveals method of obtaining 12 spindle speeds within any of the three standard ranges provided by the pick-off gears. Gears are chrome-manganese steel forgings heat-treated and oil hardened.

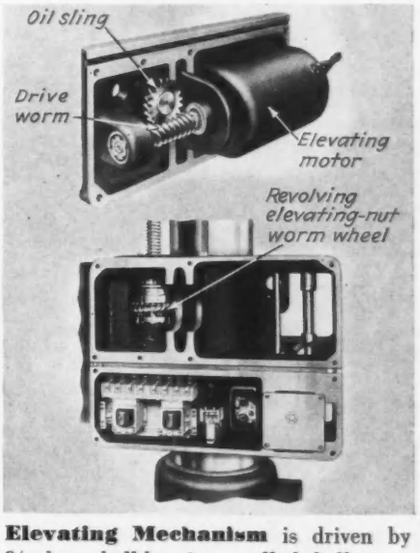
Main drive gears have ground teeth and are finish-lapped under light predetermined load, for smooth, quiet operation. Shafts are hardened SAE-4145 chrome-moly, with multiple splines and lands ground for accurate fit.



Feed Mechanism is inbuilt at front of head. A sliding jaw clutch, which drives feed worm, disengages hand feed wheel and engages output shaft of sliding-gear unit when power feed is desired.

Feed wormwheel is Meehanite and is integral part of friction cup which, together with expanding band, forms a friction clutch that is operated by the feed-engaging and quick-return levers. Clutch is so designed as to protect against overloading. Spur gear (on same shaft as quick-return levers but not visible) meshes with idlers driving feed-rack pinion shaft, thus effecting feed motion.

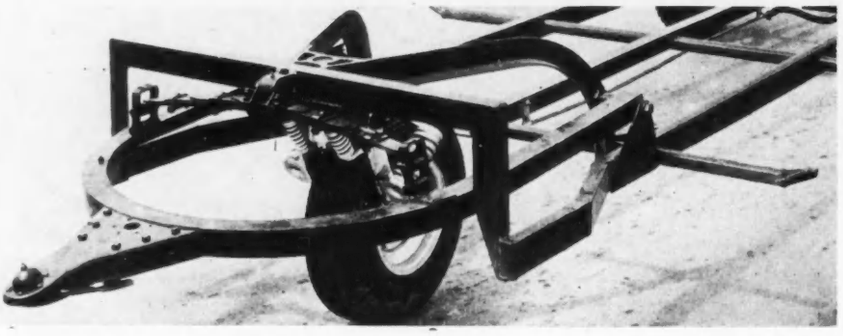
Cam and safety dogs on rear face of graduated dial automatically actuate power feed trip either at preselected depth or at extremes of travel.



Elevating Mechanism is driven by ¾ hp., ball-bearing, rolled-shell type reversing motor that is mounted on cover plate (shown folded back) and, together with magnetic control, is compactly inbuilt at rear of arm girdle. Control switch is interlocked mechanically so that elevating motor can run only when arm is unclamped, main-drive motor only when arm is clamped.

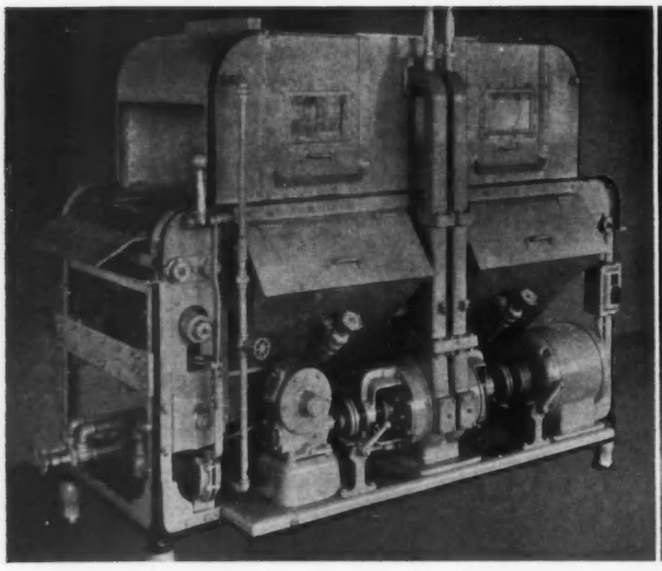
Modern Designs—Wishbone Coupler and Third Wheel on Trailer

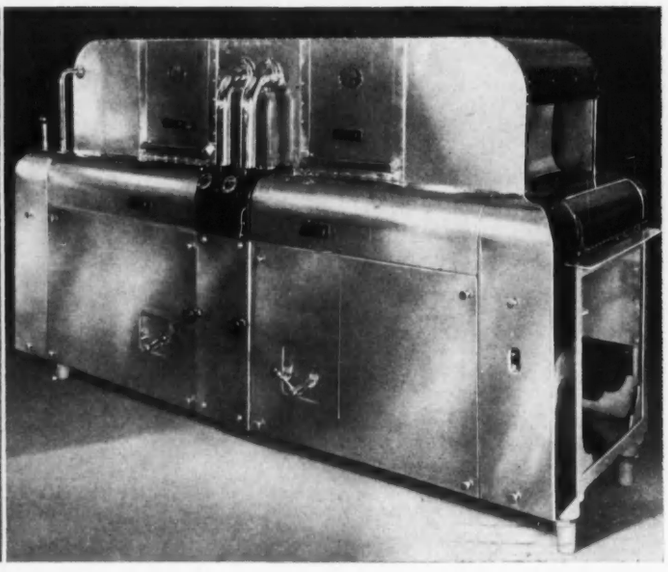
PURPOSE of design worked out by Saginaw Stamping & Tool Co. was to make available a vehicle which would have capacity for truck loads but which could be hauled by any light tow-car having the required pulling power. This was accomplished by means of the undercarriage construction, shown here, which uses third wheel to relieve tow-car rear axle of all or part of front trailer weight.



Self-Aligning Third Wheel is suspended by knee-action caster unit, the latter being adjustable to take all or part of front trailer load. Trailer is connected to tow-car through hinged wishbone coupler. Frame is welded.

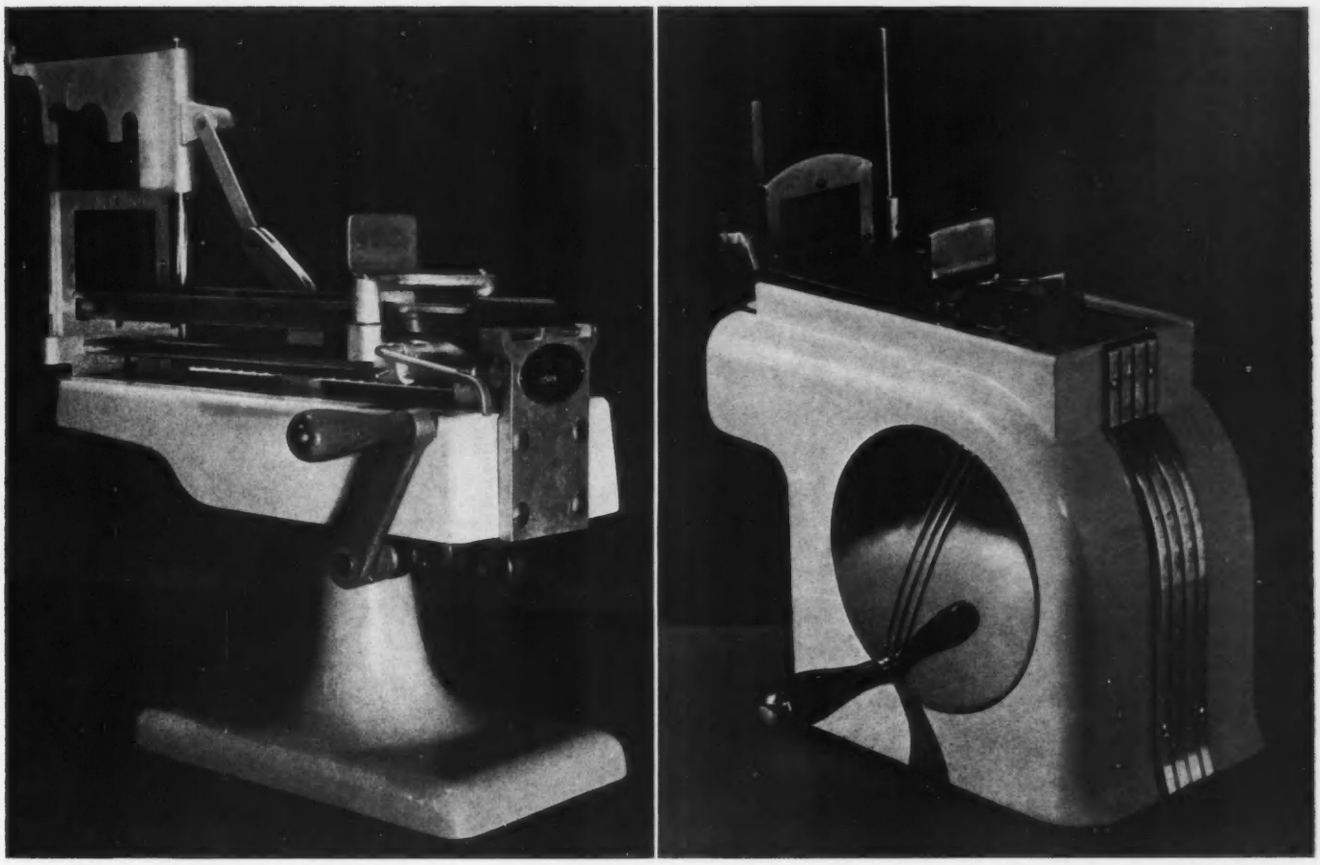
Stainless Housing Incloses Redesigned Commercial Dishwasher





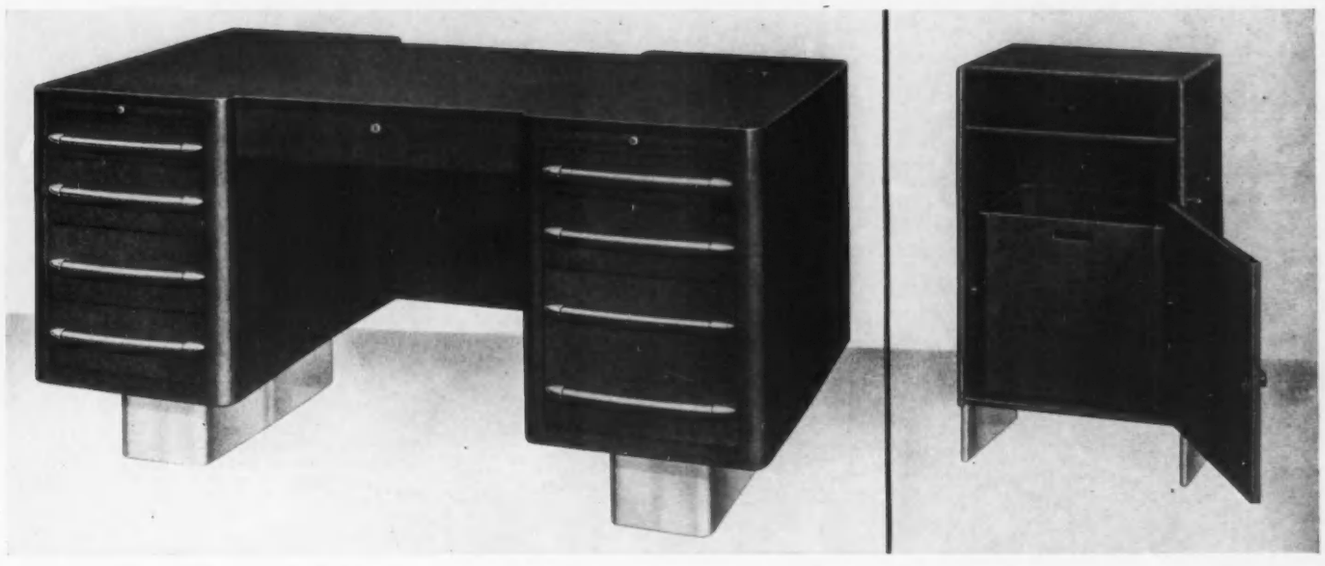
Not Just a Facelifting, the redesign by Egmont Arens of the Hobart Manufacturing Company's progressive carrier dishwasher included more efficient integration of the component equipment. This in turn permitted use of a stainless-steel housing of rounded contour, avoiding the surfaces which formerly had a tendency to collect dust and dirt.

Modern Designs—Better Looks, Easier Operation from Redesign



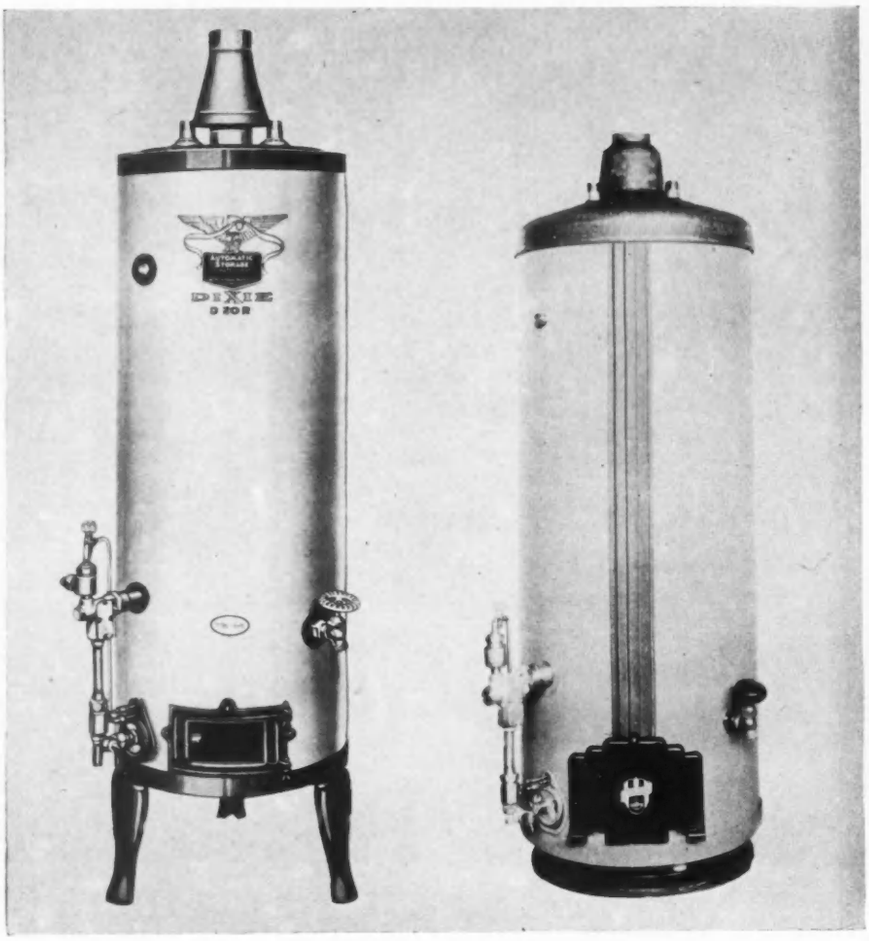
Old and New Butter Cutters, by Strite-Anderson Mfg. Co., show how new porcelain-enamel case houses all parts unnecessarily exposed in old design. Tray-return mechanism now requires but one instead of two operating motions. An integral part of crank, the chrome disk also serves as contrasting trim. Redesigned by Barnes & Reinecke.

Pressed Wood and Stainless Steel for Scuff- and Mop-Resistance



Modern Furniture Line, including desk and 'phone cabinet shown, is made largely of form-rounded Masonite Tempered Presdwood, with "mop-proof" bases of stainless steel and full-length chrome drawer pulls. Density of pressed wood material gives practically scuff- and chip-proof surfaces. Styled by Grover J. Daly for Imperial Desk.

Modern Designs



Less Cumbersome is the appearance of the new Hotstream water heater, when compared with old model at left. Effect was achieved by eliminating legs, refining top shape, restyling door, and adding fluted molding to tie base to top. Redesigned by Lawrence Blazey, Designers for Industry.

Compact Fan Unit, by Sturtevant, has propellor mounted directly on reducer-unti shaft of Reliance gearmotor. Use of 1,750-rpm. motor for 420-rpm. fan raises power factor and efficiency.

Plastic Reel is corrosion-proof and light in weight. Molded of high-impact-strength Durez by Eclipse Molded Products for Weber Lifelike Fly Company.

RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

So as to conform more closely to the shape of a man's hand, the housing of the Onsrud air turbine grinder has been redesigned. Sharp corners have been eliminated and it is now more easily held. The new machine constitutes a good example of redesign solely for better user convenience.

Since the load imposed on the drive motor of a pulverizer varies with the kind of material being pulverized, the feeder should be kept adjusted to maintain full load for maximum efficiency and output. It is therefore desirable to provide the operator with visual indication of the load, and for this purpose the General Aniline Works Inc., Rensselaer, N. Y., is successfully employing a conduit-mounted Westinghouse detachable ammeter on a machine powered by a 20 hp., 440 volt, 3 phase, 3,600 rpm. induction motor.

Cooler Iron Handle—Triple-spring front support and extended-surface ribs on rear support radiate heat, reducing temperature of handle. Designed by R. I. Huffman of Dover Appliance Co., molded of Bakelite by General Industries.

CLEANING PROCESSES

For Product Finishes

J. DELMONTE

A discussion of different methods for cleaning metal surfaces in preparation for subsequent organic or chemical coatings

THE development of substantial finishing materials and processes and their application to manufactured articles have enriched product designs. It is with this thought in mind that the average manufacturer closely follows the developments of finishing materials that are applicable to his products. Too often, however, he may be slightly confused by the number of materials and methods that purport to fulfill his requirements. At that time, a careful reiteration of the comparative qualities and respective limitations of the finishing materials becomes necessary. From the technical data released by manufacturers of finishing materials and non-commercial laboratories, a reasonably accurate survey may be made. After ascertaining the finish that will display the product to the best advantage, the manufacturer will find that a reliable firm, specializing in finishing materials of his particular requirements, will gladly cooperate in obtaining the best results—even to the extent of absorbing some of the experimental costs.

It is essential that the conditions under which a product is to exist or to operate must be clearly defined. For example, when using the term 'corrosion resisting', one must specify whether it is to be resisting to salt water, industrial atmosphere, certain gases, acids, alkalis, outdoor exposure, indoor exposure, etc. Some finishes are better suited than others to specific corrosion influences. Other products may be subject to abuse due to repeated handling, necessitating chip-proof and scratch-proof finish.

After an analysis of the article in terms of its probable use, the class of finishes that will give the best results, may be decided upon. It remains to select the method of application that offers the best economy. The methods of applying these protective coatings will often be influenced by the physical dimensions and mechanical design of the product, and the number of units to be protected. Some products lend themselves to continuous automatic finishing operations, while others require individual hand operations. In any event, the selection of finishing materials and methods should not be standardized to the extent that it would be costly to change to a new method of finishing, for the progressive manufacturer must be ever alert to new developments which may insure better results than hitherto attained. In the better finished article lies increased sales appeal and greater economies. Not only do durable finishes insure long life for the products, but they also create good will among the consumers.

Classification of Finishes

Durable finishes are readily classified in terms of the materials constituting the protective coating:

1. Chemically treated surfaces (phosphating, chromating, oxalating and oxidizing).
2. Metallic coatings (nickel, zinc, cadmium, chromium, copper, etc.).
3. Organic coating (paints, varnishes, enamels, lacquers).
4. Miscellaneous organic coatings (rubber, flock, and novelty finishes).
5. Combinations of any of the above.

As a prerequisite to all durable protective coatings, a thorough cleaning and rinsing of the surfaces to be protected are essential. Good coatings are not obtained upon objects that are greasy, or covered with a loose non-adhering oxidized film. The application of the coating should be preceded by cleaning and degreasing in successive operations. The appearance of oils, greases, waxes or gums upon metal surfaces is unavoidable where stamping, drawing, milling, cutting, oil tempering and similar operations are involved. Dirt and grease accumulate on objects from handling, buffing, fabricating, or even by the condensation of a slight film of oil that permeates every machine shop. It is for these reasons that no applied finish can hope to exhibit its best results unless the proper cleaning procedure has been followed.

A wide variety of materials has been used at one time or another to clean metal surfaces. Included in this group are alkali baths, gasoline, benzene, carbon-tetrachloride, kerosene, and others. All except the alkali baths and the gasoline have been superceded by improved methods and materials. Gasoline is still used to a limited extent for degreasing large machine parts that cannot be handled by the degreasing equipment.

Before choosing a cleaning procedure, it is essential to know the composition of the metal to be cleaned and as much as possible about the foreign material to be removed. The cost of the cleaning operation depends on the nature and amount of foreign material on the surface.

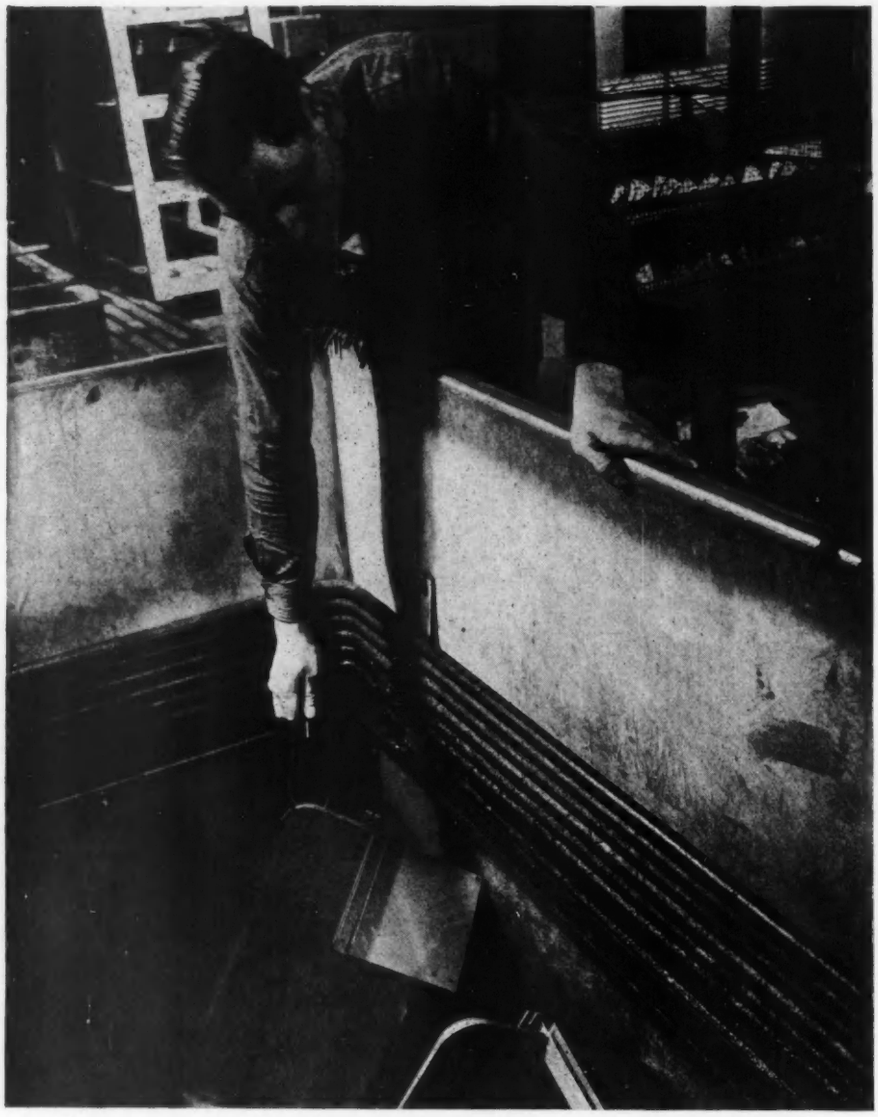
Alkali cleaning is the most common

Table I—Comparison of Acid Cleaning Processes

(As Applied to Automotive Bodies)

Wet Process	*Dry Process (For Mild Surface Rust)*
Brush or dip application of acid cleaners.	(1) Spray thin acid cleaners on surface
Scrub surface with steel wool.	(2) Dry in oven at 190-230°F. for 10 to 15 minutes
Water wash—cold, followed by	(3) Remove powdered residue with brushes or steel wool
Wipe with damp cloth	(4) Wire brushes, rags, compressed air to remove final patches
Oven dry 150-200°F.	(5) .....
Wipe with rags dipped in alcohol and water.	(6) .....

A summary of the more popular, current cleaning and degreasing methods is given in Table II.



Vapor degreasing—the action is instantaneous, the vapor, such as trichloroethylene condensing on the relatively cool metal, dissolving the grease and running off

and widely used method for cleaning metal. The process is carried out by: (a) pressure spray, (b) immersion (still tank).

The pressure spray method of cleaning is accomplished by washing machines usually with two or three stages connected by a continuous spray housing to confine the steam and spray. Each stage consists of a tank with suitable heating means, a circulating pump drawing from the tank and discharging through suitably arranged sprays to play on the work. The work to be cleaned may progress through the equipment either on a horizontal wire mesh belt or on hooks connected to a monorail conveyor chain. Usually the first stage of washing machine is prepared by charging the solution with from 1/8 to 3/4 ounces of a suitable alkali cleaner to each gallon of water contained in the tank. The cleaners used may be compounds of caustic soda, sodium carbonate, sodium bicarbonate, trisodium phosphate and sodium silicates. The second and third stages are usually hot water overflowed to keep them clean and used as rinses to remove the alkali left on the work from the first cleaning stage. Heating in the washing machine is essential and temperatures around 180 deg. F. should be maintained for best results.

Alkali cleaners are sometimes used in still tanks for removing oil, grease or other foreign matter from work by suspending it in a boiling solution of such a cleaner for a period of not less than 5 minutes and usually a longer period, depending on the amount and type of foreign matter to be removed. The usual build-up of a cleaning solution for a still tank is from 4 to 8 ounces of alkali cleaner per gallon of water. A thorough, clean hot water rinse is used after this operation to remove any alkali cleaning compound remaining on the surface.

Among processes, for which a preliminary, warm alkaline wash is generally used, are the phosphating treatments. A thorough rinse, following the alkaline wash removes all traces of substances that might contaminate subsequent processing solutions. Copper is little affected by alkaline solutions and brass is only slightly affected. But aluminum is rapidly attacked. Hence care must be exercised in the selection of the alkalies and the concentrations used.

Vapor Degreasing

Among the most prominent of the organic solvents that have been developed for degreasing the metal parts are the chlorinated hydrocarbons, perchlorethylene and trichloroethylene. The latter is used extensively today in large tanks, such as shown in the accompanying illustration. The trichloroethylene is vaporized by steam-heated coils at the bottom of the tank, its boiling point being 87 deg. C. The vapor is, on the average, four times as heavy as air, and if not over-heated will rise to a certain level in the tank and no higher. The greasy, oiled, or waxed parts are lowered into the vapor, either by hand for medium size parts, or by a screened bottom tray for small machined parts. The action is instantaneous, the vapor condensing on the cool metal parts and the dissolved grease running off in a steady stream. The total surface area of the part, the time of immersion in the vapor, and the concentration of the vapor influence the rate at which more solvent must be added.

The advantages of vapor degreasing are not so evident for thin gage panels where the actual mass of the metal is small as compared to the total area. In other words, the heat capacity is small, and the part rapidly reaches the temperature of the vapor after which the condensation of trichloroethylene on the panel proceeds very slowly. Spot welded flanges and complicated shapes are also typical assemblies that may not receive the optimum degreasing advantages in a vapor tank, as the possiblity exists of trapping the solvent and grease between the flanges or in cupped sections.

Vapor degreasers will remove oils very thoroughly. The solvent will not attack soaps to any great extent, consequently if they are to be used, soap type drawing compounds must be eliminated. Even with the spray variation, inert, insoluble material is not removed. Some form of wipe must be used to remove residues of drawing compound pigments, factory dirt and lint, or magnetic steel slivers which the degreaser leaves untouched.

Acid cleaning immediately before the application of a protective coating has several advantages. Oxides and inorganic impurities will be dissolved; the effects of a previous alkaline treatment will be chemically neutralized, and a slight etch

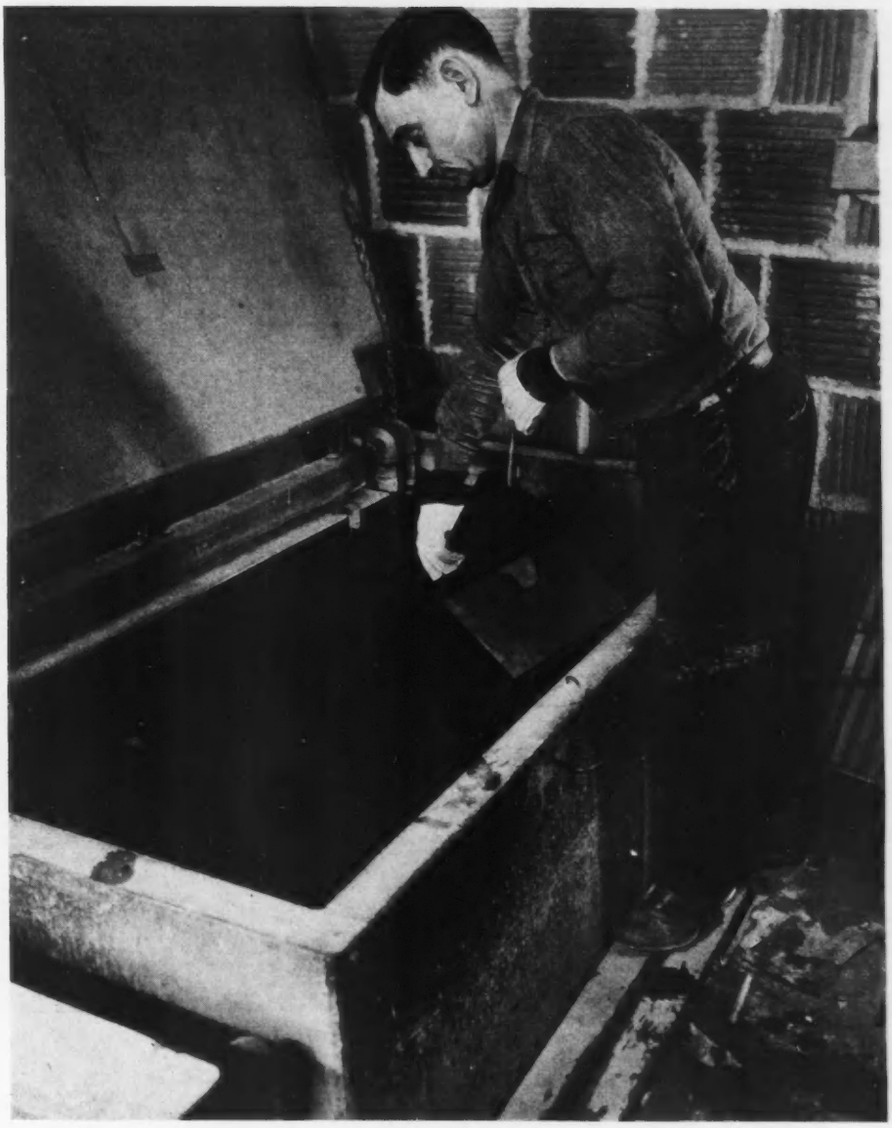
will be given to the surface, promoting better adherence of the finish.

All oil and grease should be removed from the metal before acid treatment; otherwise, the pickling will be uneven and spotty. The most common acid used for this purpose is sulphuric at concentrations of 4 to 10 per cent. The bath is used hot, 180 to 200 deg. F., and if properly maintained, ordinary mill scale occurring on hot rolled stock may be removed in 6 to 15 minutes. Usually an inhibitor is used to lesson the attack of the acid on the base metal after the scale is removed. Following the acid pickle, the work should be thoroughly rinsed in clean water to remove all "pickle salts."

All traces of acids must be removed as their presence is detrimental to subsequent protective finishes or the reagents involved in the production of those finishes. Also, too long an exposure to the acid dip should be avoided.

The acid cleaning processes, such as Deoxidine, developed for the automotive industry for the passivation of rust stimulators, are outstanding examples of the effective elimination of rust on steel bodies prior to the application of further protective coatings. A wet process, designed to eliminate rust, and other impurities, was particularly effective in counteracting the acids employed in soldering. A milder dry process was developed, as soldering acids were used less frequently with the appearance of projection and seam weldings on automobile bodies. The two processes are compared in the accompanying table.

[The author is indebted to V. M. Darsey of the Parker Rust-Proof Company and J. O. Shellenberger of the American Chemical Paint Company for their criticism of the manuscript and contributions of data.]



Alkaline cleaning requires the parts to be boiled for a relatively long time or to be treated electrolytically in an alkaline bath

Table II–Cleaning and Degreasing Methods

Type	*Reagents*	*How Applied*	*Applicable to*	*Unsuited for*
Solvent Vapor	Trichlorethylene	Concentrated vapor in tank	All small and medium size metal parts (grease removal)	Thin gage panels
Alkaline	Mild solution of NaOH (typical)	a. Boil in bath b. Spray, or c. Electrolytic	All metal parts	a. Rapid production when mininum time is required. b. Aluminum
Acid	a. Phosphoric acid b. Sulphuric acid and/or c. Hydrochloric acid d. Solvents, wetting agents, phosphoric acid ("Deoxidine")	a. Brush, or b. Dip (Wet or Dry Process—see text)	All metal parts, particularly iron and aluminum	a. Parts that are to be stored prior to application of final coating. b. Parts to be subjected to extremely severe corrosive conditions.
Combination of the other types.	See above	See above	All metal parts	

Courtesy Cleveland Tractor Company

DROP FORGINGS

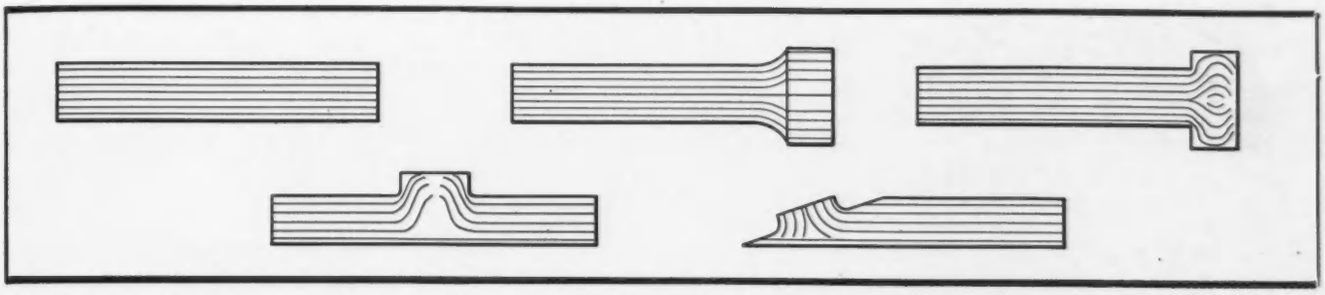
Why They Should Be Streamlined

First of a series of articles wherein designers, metallurgists and forge shop superintendents explain the essential requirements for correctly designed parts to be made as drop forgings

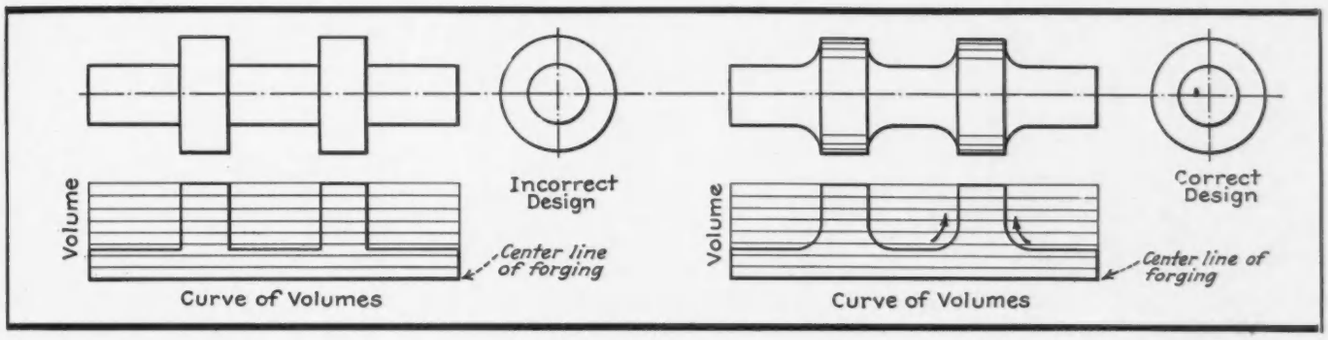
IT IS EMPHASIZED that the examples and illustrations shown in this first article point out the ideal conditions that the designer should aim at but which could be achieved completely only in the simplest designs. Articles in successive numbers of *P. E.* will develop this subject further and show how by the use of good judgment and sound compromises, the fundamental considerations set forth here can be applied to advantage. Regardless of the complexity in the shape of the drop forging, the best design is one that is "streamlined," has generous fillets and no abrupt changes in volume of metal at adjacent sections.

We are indebted to L. E. Scrannage, superintendent of The Cleveland Hardware & Forging Company for the information relative to streamlined design and the cost factors involved, to G. T. Williams, chief metallurgist of Cleveland Tractor Company for the data on flow lines and grain structure, and to Waldemar Naujoks, chief engineer of The Steel Improvement & Forge Company for the examples of intricate drop forgings.

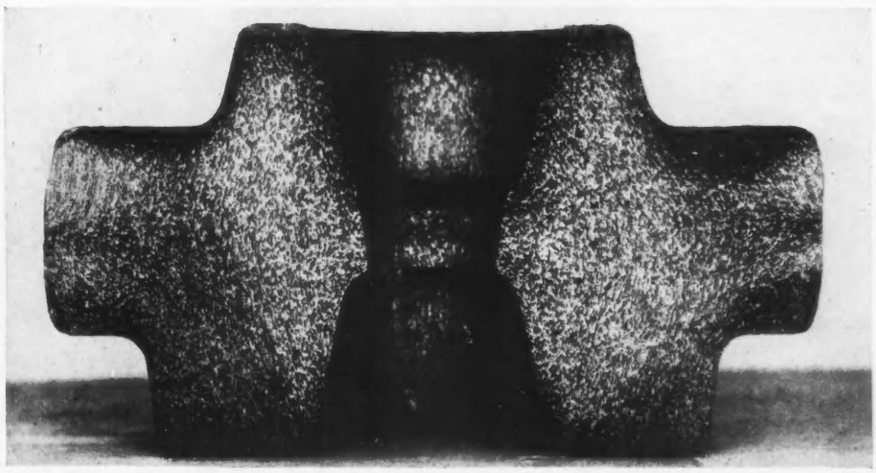
Drop forging is essentially the plastic forming of metal. Whether the material be steel, brass, bronze or aluminum, the ideal design of forging is one wherein the metal of the bar stock will be displaced to fill the cavity of the die with substantially no excess metal and will accomplish this without an excessive number of hammer blows. The better the flow conditions the less will be the amount of excess metal to form flash, an excess amount of which will prevent the pressure of the hammer blow from being exerted upon the forging proper to cause plastic flow. But the shape and dimensions of the finished drop forging should be such that the metal in the rough forged stock will flow, without undue hindrance, in such a manner as to fill the cavities in the forging die completely without excessive hammering.



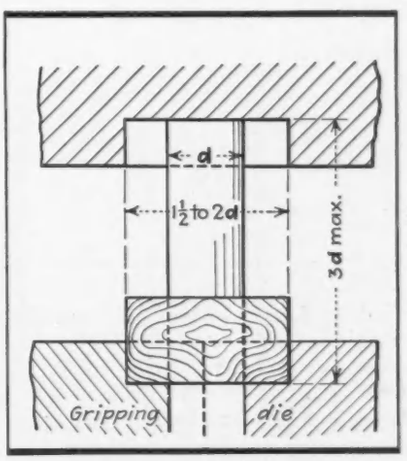
Most metal forgings are made from bar stock wherein the lines of the fibers run parallel to the axis. As pointed out by G. T. Williams, chief metallurgist of the Cleveland Tractor Company, the best result is obtained when the forging pressure is applied along the axis of the piece. This will be the best condition for compelling the metal to flow without bad distortion of the fiber lines. If the metal is compelled to flow in a direction perpendicular to the lines of the fiber, by pressure applied in a direction perpendicular to the grain, as when a boss is raised upon a flat plate and machined the metal will not be as strong in its resistance to impact loads especially. A worse condition for resisting impact stresses will exist when the metal is compelled to flow in a direction at an angle to the direction of the grain and the load is imposed in a direction across the grain. The worst condition is a boss that is machined across grain.



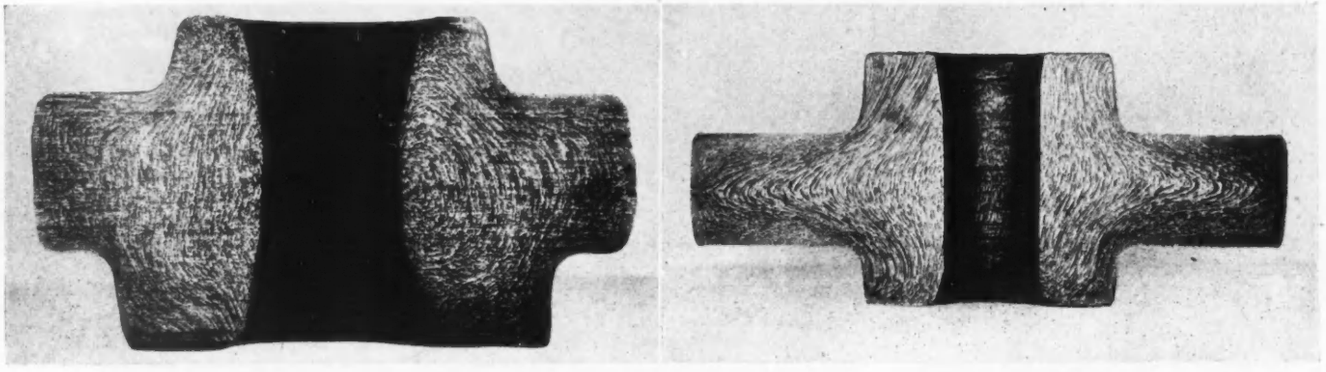
A curve of volumes should be plotted to determine if the forging has been designed for best forging conditions. If this curve contains sharp corners it indicates poor flow conditions. However, if the part has been designed with generous fillets there will not be any abrupt changes in metal volume between adjacent sections as shown by the curve above. The best design would be one wherein the volume curve changes smoothly and not too abruptly at points where the volume is increasing. This will also indicate the most economical forging to make with respect to cost. Poor flow conditions will cause an excessive amount of flash thereby necessitating an excessive number of forging blows and favoring the formation of cold shuts, the metal not filling the die cavity completely. Cracks, shuts and similar defects are also liable to result if the distribution of the metal around the neutral axis is unsymmetrical.



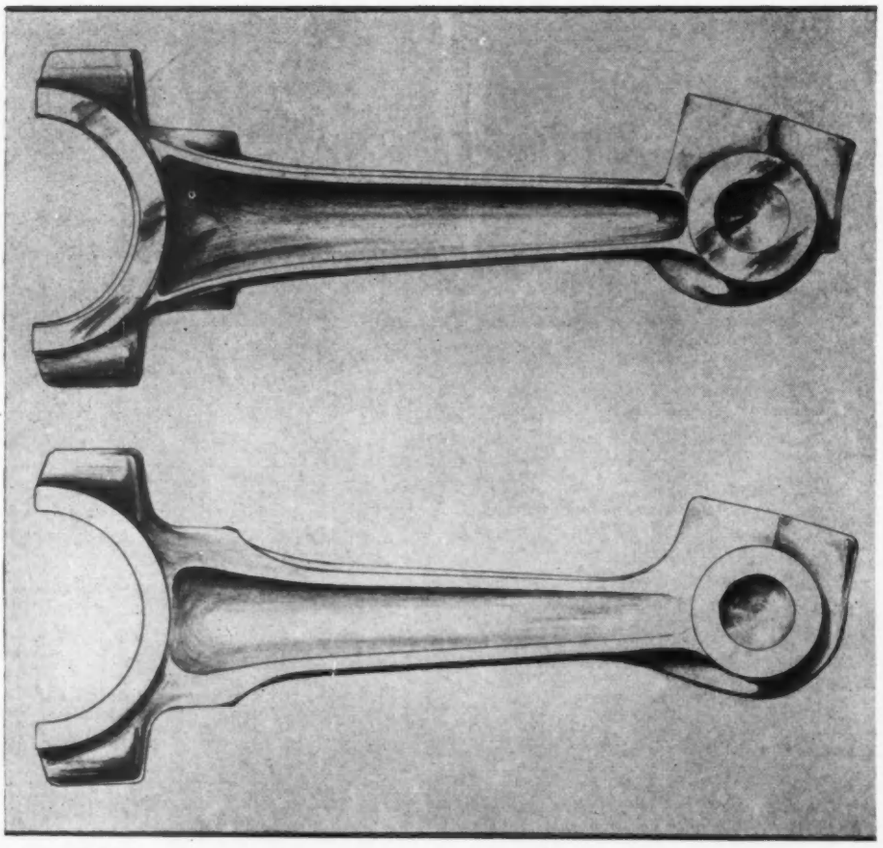
Number of blows required also affects the machinability of the material. If the forging requires too much hammering the fiber lines become broken. If hammered too much the metal becomes excessively "dense." The latter makes machining more difficult. The etched cross-section of the gear blank shown here was forged from a 4-in. square bar of SAE-3115 steel and purposely insufficiently hot-worked. Note the almost complete absence of flow lines. Excessive hammering is required when the plastic flow conditions are poor, which is also conducive to cold shuts, cracks and excessive amount of flash which, chilling rapidly, interferes with the forging operation. Properly designed forgings will show the flow lines distinctly when sectioned and etched.



In making upset forgings the bar stock is rough upset and is usually so proportioned that the upset ratio on the diameter will be from 1½ to 2, the length upset ratio usually from 2 to 2½, with 3 as a maximum. If greater than 3 diameters, the bar will usually buckle. However, length upset ratio may exceed 3 diameters if additional die and operation cost is not prohibitive.



Gear blank forged from a 3 in. diam. bar of SAE-3115 steel. The diameter upset was 1.7 while the length upset was 2.1. Note that the direction of the fibrous grain structure is such that after the gear has been cut the tooth load will be in a direction across the grain and not with the grain. The gear forging shown to the right was made from SAE-3115 steel. The diameter upset was 1.5 and the length upset ratio was 3.1. This shows how the large fillets permitted the metal to flow laterally, the grain flow lines not showing crowding or sharp changes in direction.



Streamlined symmetrical design of drop forgings also avoids possible trouble in the heat-treating. It is recognized that regardless of the design, heat-treating may cause warpage or distortion. But by careful design it is possible to make the piece of such shape and proportions that distortion will be a minimum, will always be the same in successive pieces and will not necessitate the addition of straightening operations.

Sharp deep pockets must also be avoided in the design of drop forgings. Here are shown two identical designs of connecting rods. The original design contained deep crevices and sharp corners. As pointed out by L. E. Scrannage of The Cleveland Hardware & Forging Company, by the addition of a small amount of metal these were eliminated in the redesign. Generous fillets greatly improved the plastic flow conditions, made possible a better grain structure in the drop forging and eliminated possible points of stress concentration. Also, the absence of sharp fillets and corners, increase the life of the forging dies both because a fewer number of blows are required to make the piece and because the wear on the dies at sharp corners is reduced to a minimum. By eliminating corners and deep pockets, it became possible to clean the drop forging easily whereas the original design required costly cleaning operations.

Succeeding articles, including one by Waldemar Naujoks, chief engineer of The Steel Improvement & Forge Company, will explain the fundamental principles to be observed in the design of more intricate drop forgings such as those shown above and L. E. Scrannage of The Cleveland Hardware & Forging Company will explain additional fundamental design requirements.

CASTINGS IN DESIGN

The Place of Cast Construction in Engineering

The author is metallurgist and engineer of a prominent steel company equally interested in selling both structural steel and castings. He presents a refreshing view of the place of castings in engineering and their relation to welded construction

OBVIOUSLY, it is absurd to propose that all patterns should be scrapped and foundries padlocked and that everything should be welded, riveted or bolted from rolled shapes. And it would be almost equally absurd to propose that everything be cast. Each of these methods of joining members or producing them in whole has its place in engineering.

Selection of Material

One important step in sound engineering design is to select that material and process of manufacture which is most suitable for the part under consideration. To insist on concrete for airplane struts because one loves concrete or to use pine wood for firebox doors because one likes wood construction is no more absurd than selecting a material because its name sounds nice. Phobias do not result in sound design or construction except accidentally, and yet, the absurdities just mentioned are not much more far-fetched than some phobias in design using metallic materials. The engineering profession owes a great debt to the welders, but that debt is no greater than that which they owe the foundries.

The foundry is the starting point of the steel business. Steel is cast into ingots before rolling into sections or being hammered into forgings. The ingot form is much more simple than that possessed by most castings encountered in a foundry, but the principles observed in producing a good ingot are the same as those underlying the making of a good intricate casting.

Structural columns formerly made of cast iron have been practically superseded by columns of rolled steel sections. The reason here was basically an economic one. Building codes and specifications have been written to take advantage of the fact that standard rolled sections can be secured at a very low cost which can be obtained only when large tonnages of a section can be rolled. However, for special conditions the casting still fills a very definite need.

Contrary to some opinions the foundry has no quarrel with welding. The foundry welcomes the development of welding. Advances in the art of welding, particularly acetylene and electric, have made usable many castings which formerly had to be rejected because of some minor defect or a flaw in their appearance. Incidentally, a very peculiar idea exists in the minds of many people in connection with the foundry and welding. One is always amazed at an engineer who refuses to sanction the most perfunctory welding of minor repairs on a casting, but, with the utmost assurance will weld the most important parts with never a thought to annealing, to the soundness of the welds or to the technique of welding. Furthermore, but not so incidentally, if one is looking for good welders they can be found in the foundries. There the importance of good welding technique has been realized and highly developed.

It is interesting to note that both electric and acetylene welding are casting processes, usually with an open metal mold instead of sand. However, both of these processes are handicapped by not having heads to feed the shrinkage of the metal as it cools.

Structural Zone

In fusion welding, molten metal is deposited and fused with the parent metal. But using rods of the same analysis as the parent metal so that the analysis from parent metal to weld is the same, will still result in very apparent differences in structures evident in definite zones. Whether these structural zones have a detrimental effect or not depends on the material used and the technique employed. In connection with the sound practice of welding on castings it is appropriate to point out that these structural zones are less apparent when the parent metal is as cast, probably because the grain structure of both parent metal and weld are undisturbed.

For a number of reasons, some of

Fig. 1—Casting ingots is the first foundry operation in the steel business. The principles followed in producing a good ingot are the same as those observed in making a good intricate casting

which overlap, good design may dictate the use of castings:

1—The requirement of unusual sections or shapes.

2—Special analysis of material in small quantity.

3—Economy.

(a) In material.

(b) Cost.

4—Safety and strength.

Special sections and shapes have already been discussed to some extent. For heavy machine tool beds, where inert weight is essential, the use of cast iron seems sensible. It is true, that simply for strength, welded standard sections could be used for many applications where inertia is of no moment. Where shapes can be used to advantage it is good design to do so.

For hydro-electric turbine covers and cases cast design is not excelled. This type of design provides a desirable rigidity to the structure which is not obtained by other methods of construction, because the cast structure has the same strength and stiffness throughout and does not have joints which may become loosened or fatigued from vibration and shock.

Elimination of Joints

Other applications where castings are very satisfactory are railway car side frames, bolsters and coupler yokes. No other car bolster has yet been designed which can withstand the shocks and vibrations in a manner comparable to the cast steel bolster. The same is true of the truck side frame and coupler yoke to the extent that the standard A.A.R. specification is for cast steel. Weight is not needed here and many of these parts have cast steel sections ¼ in. and ⅜ in. thick. Thousands upon thousands of these castings are in service with very few cases of failure. The scarcity of failures is the chief reason for standardizing on castings. The side frame and bolsters being in one piece obviate working joints. This style of construction makes for better wearing qualities and reduces maintenance costs.

Where special analyses of material are required for a specific purpose, castings again merit consideration. It is not always easy to fill special requirements in rolled steel even though suitable sections can be rolled. An application that can be recalled is a special bronze for a particular corrosive condition where neither section nor analysis was available. Special bushings are frequently needed in bronze, iron or steel for specific purposes or service requirements.

Apropos of these considerations a certain prominent manufacturer of porcelain insulators who formerly used a forged cap for his suspension units now uses malleable iron castings. The modulus of elasticity of steel was too great, and note this, accurate fits could be secured only with excessive cost. To secure reliability and to avoid shearing the porcelain by contraction of the cap, a change was made to malleable iron. Last but not least the malleable caps in addition to being better for this application could be made much cheaper.

Waste in Machining

Economy usually dictates the final selection of materials for most applications. When castings are used there is little waste of material in machining. This is a natural advantage of cast construction, especially where large numbers of one casting are required when the saving may be great.

Steel castings should be annealed after welding operations of any consequence. However, many engineers who are quite insistent on this point will accept an unannealed welded part without question. A sound steel casting well annealed provides a structure whose strength is uniform and dependable throughout. This uniformity and strength obtains at points where joints would occur in a fabricated structure. This reference to "sound" castings may need emphasis as it is found that many still cling to the antiquated definition pronounced by an old professor that "a casting is a mass of holes surrounded by an unmachineable mass of metal." If the large number of castings used is considered, it can be

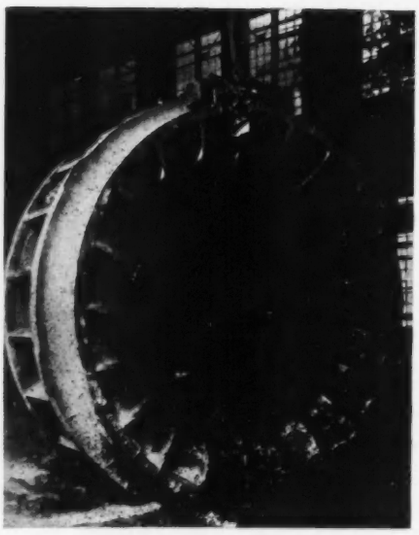


Fig. 2—A design wherein the cast type of construction excels — curved surfaces of thin sections and intricate cavities

readily seen that castings having concealed defects are the exception rather than the rule. Concealed defects do occur, and they also occur in other materials of construction.

The progress made in the art of founding is not sufficiently appreciated. The skeptic can secure X-ray pictures of castings to assure himself of their soundness; however, those familiar with foundry practice can usually predict the quality from an examination of the casting and the method of molding. Where a large number of castings are to be made from one pattern, sample castings are frequently broken or drilled as a check before regular production is started. This preliminary inspection insures that with consistent molding practice the lot of castings will be sound. There is nothing mysterious about molding and foundry practice. The art is becoming more of an exact science than many of its contemporaries, whereas a few years ago it was a profound mystery

Fig. 3—For turbine casings and covers cast design provides a desirable rigidity to the structure which is not obtained by other methods of construction

to most engineers not to mention laymen.

This mystery has been a distinct handicap to the use of castings in design, because many engineers had neither the desire nor the opportunity to become familiar with this very useful form of material, and consequently were very anxious to pass it by in favor of something which they felt they understood. Until the many "rule of thumb" methods of molding practice were analyzed for fundamentals, a sound casting was thought to be the work of a beneficent Creator who seldom looked kindly on a mold. The underlying principles of the art are becoming more generally understood, and the quality of castings is improving rapidly.

The strength of one-piece castings has been demonstrated many times. Large cast steel pipe in 20-foot lengths has been tested to 3,000 lb. per sq.in. without a "weep;" and oil well safety plugs made of cast steel have been tested to the same pressure. The United States Navy uses cast steel fittings on their high pressure steam lines on battleships for 350 lb. per sq.in. steam pressure, where a

casting failure might mean serious loss of life as well as crippled motive power.

The use of iron castings to withstand low stress is interesting. The areas on a casting corresponding to "joints" in a fabricated device have normal strength and so does the metal adjacent to these joints. The many advantageous uses of cast iron would be difficult to obtain by using a material not cast, and the conditions which cast iron satisfies economically would be difficult to meet otherwise—especially at equal prices.

Contending that factors of safety and strength are arguments in favor of the use of castings, may be greeted with some surprise. However, as has been mentioned before, the occurrence of a joint is a potential source of trouble in service when the part is subjected to severe vibration or shock. Devices of one piece have a distinct advantage in this respect, and, so far as practical, are usually incorporated in a design. It was a consideration of safety and strength as well as economy which led to the adoption of the one piece truck side frame and bolster. A structure is only as strong as its weakest link, and if a weak joint can be avoided it would seem to be sound design to do so.

Helpful Consultation

During a "spell" of designing, it is good practice to consult with your foundryman when in difficulty and to get his approval of a completed casting design. The foundryman will not intrude in the realm of stresses, strains, moments and moduli, but frequently he can tell whether the design can be economically cast, and more important, whether or not the piece will be sound when cast. The foundryman may or may not understand the designer's reasons for wanting the casting "just so," but his advice will usually be found helpful and constructive.

Steel bridges and buildings are designed with a knowledge of the means for erecting. Machines are designed with a knowledge of the shop equipment available for their manufacture and assembly. An inventor recently was greatly put out because someone questioned the feasibility of boring an opening which started out as a flared oval and ended as a square. There have been designers who expected as much from the foundryman as this inventor did of the machinist. Many casting designs are good structurally, but would benefit economically if a foundryman were consulted before the patterns were completed and delivered.

Design Precautions

A great deal has been here presented about the places where castings should be used, and about the inherent advantages to be realized but the design of the casting itself has not been discussed. The limitations in design are few although the precautions are many. It is generally assumed that fillets are an absolute necessity in a re-entrant corner or angle. Proper filleting does make the foundry job easier and the resultant casting is usually better, but fillets can be so large as to breed concealed defects and then, of course, the foundry is usually blamed.

Fillets are quite essential not only for strength of the structure but for other reasons. If it is insisted that castings have square corners and high cost is no objection, square corners can usually be secured. Fillets will do wonders in strengthening a re-entrant corner, as is witnessed by the abundant braces under the heavy coping of large buildings as well as the bead of an automobile tire.

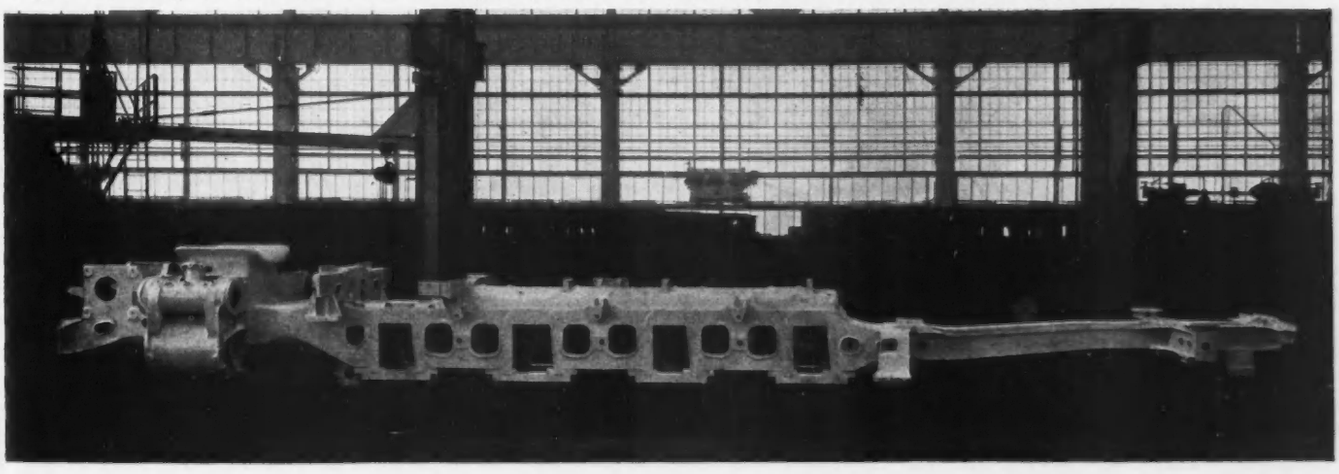
In designing castings there are, however, a few simple rules which should be kept in mind, and the first of these is to exercise care in changing size of sections. Changes in thickness of section should be made gradually, and the flow of the molten metal should be favored as much as possible. When changing the thickness of a section consideration should be given to the finish which must be added in casting, this is especially true of flanges on a barrel of any sort and neglecting this in the design is responsible for most of the troubles with barrel-shaped castings both at the foundry and in service. On the large butterfly valve bodies for Boulder Dam the barrel in approaching the flanges was swelled to nearly the same section as the flange. While this thickening of the sidewall at this point contributed a decided increase in resistance to the bending moment at this point, every foundryman who viewed the design must have been impressed with the thoughtfulness and intelligence of the designer. The second rule is to be sure that the piece can be cast economically and often the details of design which govern the pattern construction, affect this economy seriously. Small changes will frequently permit castings to be made in green sand with simple pattern equipment, which would otherwise require expensive core boxes. In other cases it may be more economical to make the design entirely in cores.

Perfection in Design

Design is an endless compromise between the ideal and the practical. The selection of materials must always be limited by that which is available and by the cost. In the industrial life of this country, the demands of designers are insistently calling for further developments and refinements of materials, and on the other hand the producers of these materials are constantly presenting progressive improvements in materials, for the further perfection of design and performance.

The progress of the foundry in the production of cast materials is only beginning. The foundry will contribute its share in the struggle for the ideal design. Someone has defined the art of Engineering as "a series of scientific approximations which become less scientific and more approximate when approaching a result."

Fig. 4—Cast one-piece locomotive bed with integral cylinders eliminates many joints and reduces number of parts and maintenance costs



RESISTANCE WELDING

Principles and Design Data

L. H. FROST
Welding Engineer, Electric Controller & Mfg. Company

In this first of a series the author explains the elements which are the basis of all resistance welding operations and which must be considered in the design of parts to be resistance welded. The second article will appear in February

GREAT PROGRESS has been made in resistance welding since the first machines, the butt welder and then the spot welder, were developed some fifty years ago by the late Prof. Elihu Thomson. The evident value of the resistance welding process as a quick, simple and dependable means for joining pieces of sheet metal increased the use of sheet metal construction, which in turn created an insistant demand for further developments in the resistance welding process. The improved machines and controls now available have made resistance welding of major importance in many industries. By the use of proper data for design for welding and the selection of the correct welding machine it is often possible to effect large savings over other means of fabrication or assembly.

In order to understand the factors which influence the application of this process it is necessary to consider the fundamental principles of operation and construction of resistance welding machines.

Welding in its original sense is a process by which two pieces of heated metal are bonded by the pressure produced by hammering. This type of weld has been used by blacksmiths for centuries. It is also the process of welding as performed by the resistance welding machine in that the weld is effected by the proper combination of heat and pressure. The heat required is obtained by causing a large current to flow through the section where the weld is to be made, the amount of heat generated being equal to the square of the current times the resistance encountered. The pressure required to forge the pieces together is applied to the electrodes which also direct the current to the desired point. Fig. 1 is a schematic diagram of the essential parts of the resistance welding process. Of the many factors which influence the results, the principal ones are:

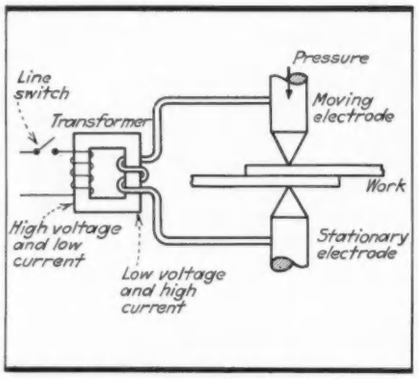


Fig. 1—Essential elements of electric resistance welding machines, regardless of the size and complexity of the machines

1. Resistance of the metals to be welded.
2. Value of the current flowing through the work.
3. Pressure with which the electrodes contact the work.
4. Time during which current flows.

In general, the resistance which is most effective is that at the contacting surfaces of the pieces being welded. This is in general proportional to the electrical resistance of the material being welded but it is always a relatively high resistance and, being concentrated, an intense heat is generated by the current. Thus the metal at the contacting surfaces is quickly heated to a welding temperature. The proper value of current is determined by the thermal characteristics of the metal being welded as well as the resistance available to produce heat. The pressure is determined by the metal, the condition of the surfaces in contact and the type of electrode material used. The welding time is fixed by the metal, the capacity of the welding machine and the type of electrode material.

When welding mild steel the proper balance between current and pressure is not as critical when the welding time is long, one second or more, as when the welding time is short. But when welding ferrous or non-ferrous alloys, the proper balance of time, current and pressure is always a critical one. This explains why there was little change in the design of welding machines until the development of the now common alloys and the demand for short welding time.

In Fig. 2 are shown two electrodes of conventional design bearing on two sheets to be welded. At the right is indicated the thermal gradient at the instant that current is applied and before the weld is made. At this instant practically all the heat is developed at the contact surface rather than throughout the work itself. That is, the greatest value of heat is developed at point *C* rather than throughout the pieces, and it is at point *C* that it is desired to make a weld.

Since the rate of heat generation depends upon both the value of the current flowing and the resistance of the surface contact areas, it is evident that either a change in current or a change in resistance will alter the thermal gradient and the rate of temperature rise of the surfaces to be wleded.

Welding machines are supplied with a means commonly called a heat regulator for varying the current. The contact resistance is determined by:

1. Electrical conductivity of the work.

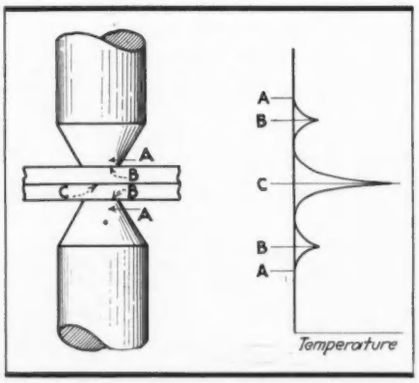


Fig. 2—Most of the heat is liberated at the contacting surfaces where resistance is high. At C the resistance must be relatively much higher than at B or the electrodes will be welded to the work

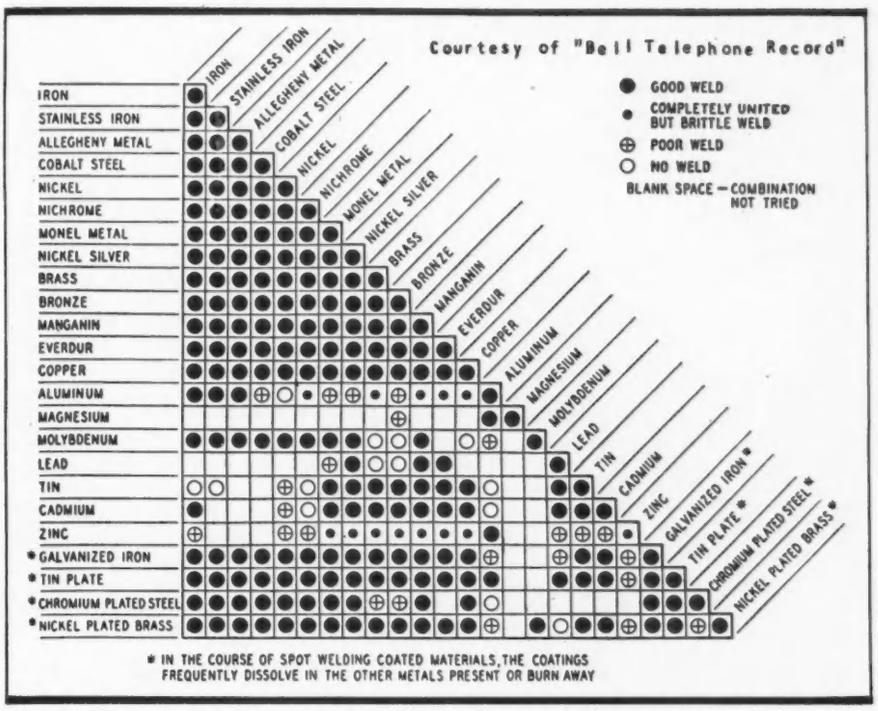


Fig. 3—Weldability of various metals. This chart was constructed by engineers of the Bell Telephone Laboratories from the results of tests

2. Surface condition of the work—rough, smooth, scaly, etc.
3. Pressure forcing the surfaces into contact.
4. Size and shape of electrodes.
5. Type of electrode material.
6. Surface condition of the electrodes.

For a given problem the conductivity and surface condition of the material are determined by the job and for this particular job the size, shape, type and surface condition of the electrode can be made to suit the job and the pressure may be then adjusted when the job is set up.

Fig. 2 shows that heat was developed not only at point *C* but also at points *B* which are the surfaces between the electrodes and the work. In welding materials, such as mild steel, which have an electrical conductivity less than the electrodes, which are usually of pure copper or a high conductivity, high strength copper alloy, the gradient will be as shown. As the conductivity of the work pieces increases with respect to that of the electrode material the maximum value of *C* will decrease with respect to *B*. If the material to be welded has the same electrical conductivity as the electrode, *B* and *C* will be equal and under such a condition the electrodes may be welded to the work, as well as the work being welded. This happens when welding copper but usually if an attempt is made to weld copper on the ordinary machine no weld is made since the machine will not have sufficient current capacity.

In alloys having a conductivity less than mild steel, such as stainless steel, *C* will be even greater with respect to *B* and to avoid burning it will be necessary to decrease the current as compared to that when welding mild steel, or to increase the pressure, thereby decreasing the resistance.

In the thermal gradient of Fig. 2 only the instantaneous condition was represented. The actual welding process requires a time period. The quantity of heat generated is the product of the current, the voltage drop across the electrodes, and the time of current application multiplied by suitable factors for heat loss, etc. Proper control of the length of time of current application has made modern high speed welding a true production process in that time is now controlled automatically.

By using proper methods and careful control of the factors outlined above it is possible to weld, by the resistance method, most of the metals and alloys commercially obtainable. Fig. 3 shows some of the various metals which have been welded. Some of these, as the chart indicates, are not good welds but the table does indicate that the resistance process is not limited to the welding of steel and its alloys.

When designing parts which are to be assembled by resistance welding there are two principal factors to be considered:

1. Materials to be welded.
2. Type of resistance welding process to be used.

Although Fig. 3 indicates that nearly any metal in common use can be welded, some metals require more careful control of the welding process. The increased cost of the set-up required for certain metals may offset the advantage gained from the use of resisting welding. As an example, unpickled hot rolled steel is easily welded but to obtain good welds consistently it is necessary to dress the electrodes frequently. Pickled stock on the other hand requires little maintenance of electrodes to obtain good welds consistently. Further, in the case of unpickled steel it is not practical in production to attempt to obtain good surface appearance. This is caused by

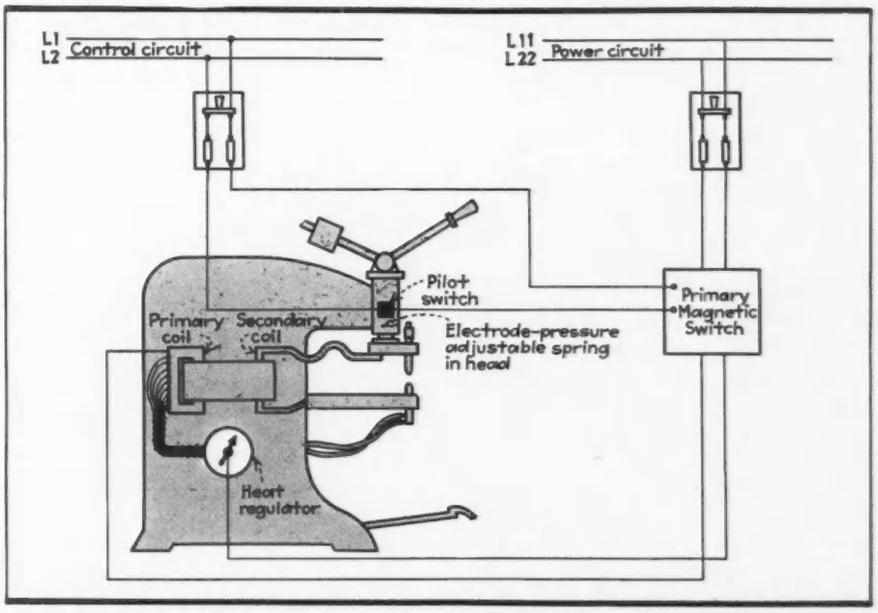


Fig. 4—Typical manually operated spot welding machine, showing the arrangement of the electric circuit

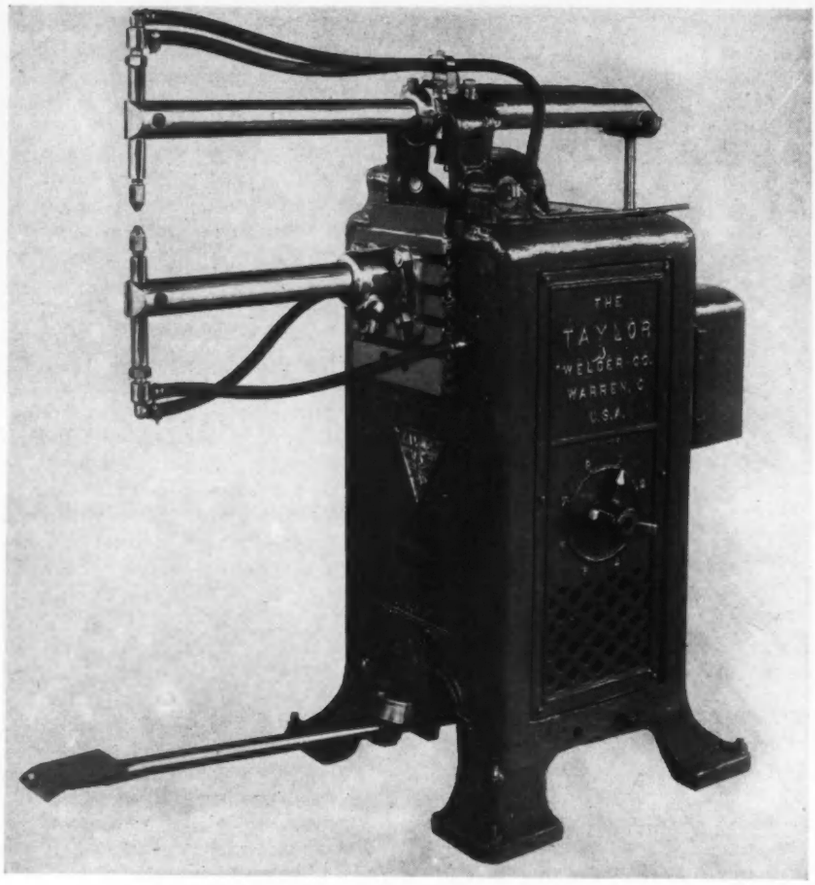


Fig. 5—Foot-operated spot welder of small capacity wherein a rocker arm is used instead of a sliding head

the heavy oxide or mill scale which causes flashing and burning at the contact surface between the electrodes and the work. With pickled stock this scale is not present and it is possible to obtain welds in production which require little or no metal finishing prior to painting. Thus, while the first cost of the unpickled stock is less than the pickled stock, the cost of the finished part will be more because of the increased electrode cost and finishing costs.

Types of Resistance Welding

Three types of resistance welding processes will be considered:

1. Spot welding.
2. Projection or relief welding.
3. Seam welding.

Spot welding is the process in which the weld is formed where the electrodes contact the work. The general arrangement of this is shown in Fig. 1. The electrode must be of a size and shape to give the desired size and shape of weld.

Projection welding employs a large electrode and the size and shape of the weld is determined by embossments or projections raised on the work.

Seam welding consists of making overlapping spot welds which form a pressure tight joint or seam. The electrodes are usually rolls which contact the work as it is passed between them. By spacing the welds instead of overlapping them a process sometimes called "intermittent spot welding" is obtained.

The choice of the process to be used is often one of economics. If a spot welding machine is available but neither a projection welder nor a seam welder is available, then the first design considered must be for spot welding. If, however, a large quantity of duplicate units are to be assembled it will be necessary to consider not only the existing machine but also the possibility of a satisfactory return on the investment in a new machine. It is also possible in some instances to change a spot welding machine into a projection welding machine. Since each type of machine operates on the same general principles each type will be considered individually.

A schematic diagram of a typical manually operated spot welding machine is shown in Fig. 4. A transformer located in the body of the machine steps down the line voltage and steps up the line current for welding. Operating either a hand lever or a foot treadle compresses a spring which moves the electrodes against the work inserted between them. After the electrodes contact the work further movement continues to compress the spring and when a definite, predetermined pressure is reached, a small pilot switch is tripped. This energizes the main power contractor, or magnetically operated switch, and current flows through the work.

Actual timing of the current flow is determined by the operator who releases the lever or treadle when he judges the weld is completed. As the treadle returns to the normal position it first trips open the pilot switch, which opens the power contact and cuts off the welding current, and then releases the pressure on the work. In many types of machines the pilot switch is closed as above but is arranged so that futher travel of the treadle will trip the pilot switch open. When the treadle is released, pressure is removed and the pilot switch is reset.

Types of Machines

It is obvious that other mechanical arrangements can be used. Fig. 5 shows a foot operated machine in which a rocker arm is used instead of a sliding head. In this machine, which is of smaller capacity, the main power circuit is operated by the pilot switch which is made of sufficient size to carry the line current. Such a switch, however, often requires frequent maintenance.

This type of machine has a definite disadvantage in that the success of the welding operation depends upon the judgment of the operator. When used in continuous production it is not possible, except with an unusual operator, to maintain either the rate of production or the quality of work throughout the working day.

The next development in spot welding machines lead to motor driven machines in which, by a suitable cam or lever action, an electric motor operated the electrodes and pilot switch. Operation of the treadle clutches the motor to the cam which operates the electrode arm and the pilot switch. The welding time, current and pressure are not under the control of the operator since the complete cycle of operation is determined when the machine is set up. The clutch is so arranged that if the pedal is held down the cycle of operation is repeated. A gear box provides speed adjustment. Speeds of 80, 100, 125 and 150 welds per min. are common.

[In the next article of this series, to appear in the February number, the essential elements of the latest types of resistance welding machines are described briefly and the author gives data on the strength of spot welds for sheets of various thickness and discusses the effect of the type of loading on the weld strength.]

Question and Comment

Felt-Washer Acts as Mist Seal For Motor Ball Bearing

J. L. BROWN
Industrial Motor Engineering
Westinghouse Electric & Mfg. Co.

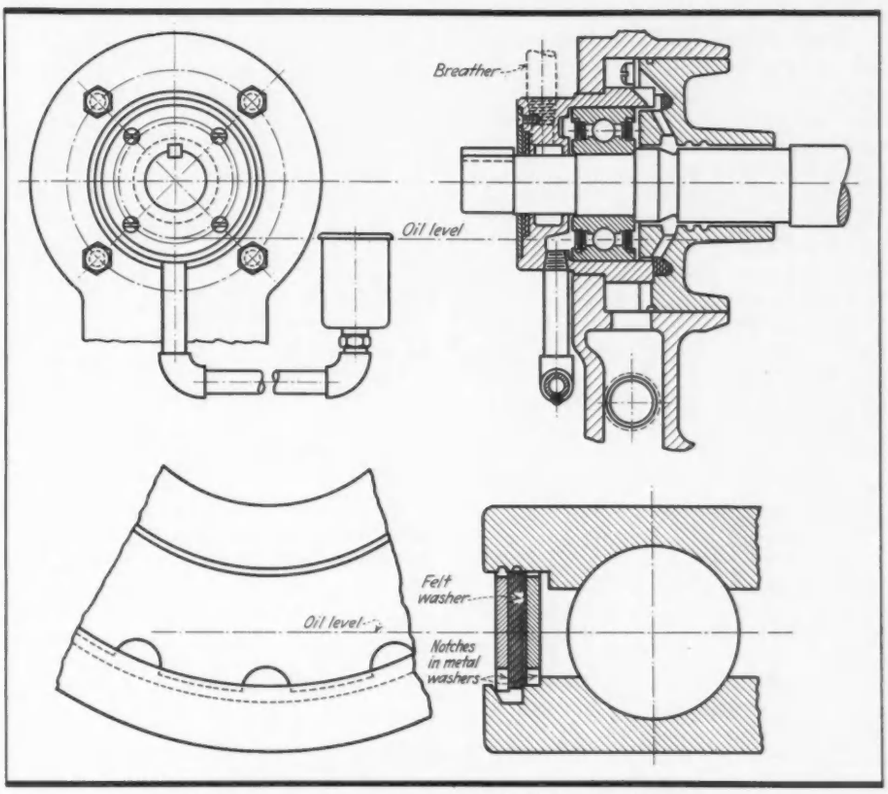
The recent extension in the application of ball bearings tc electric motors has come about largely as a result of oil leakage from the older types of housings of plain bearings and the consequent destruction of the motor insulation. In the majority of instances, ball bearings can be successfully lubricated with grease. This can be retained in the housing without much difficulty and the motor insulation is protected from the destructive effect of the lubricant.

In certain instances, however, grease lubrication has been found less satisfactory than oil lubrication, especially for higher speeds, and it therefore becomes necessary to use oil. The problem of oil-leakage into the motor is then introduced and it becomes a critical one inasmuch as the ball bearing produces much more agitation of the oil than a sleeve bearing.

The design shown by the accompanying sketches has been developed to permit the rolling elements of the bearing to dip below the level of the oil in the reservoir as they reach the lowest point of travel, thereby affording proper lubrication without developing oil spray or vapor within that part of the bearing housing external to the bearing proper. Leakage of oil from the bearing housing is thus successfully prevented.

In this design, the spray-making elements of the bearing are inclosed in a chamber which in turn is inclosed in the housing. The oil-sealed ball bearing is arranged to permit access of oil contained in the main reservoir to the interior of the bearing through a series of notches in disk-shaped metal inclosing washers having a thin felt washer sandwiched between them.

The oil passing freely through the holes in the steel washers filters through the felt washer, thus reaching the interior of the bearing from the supply in the reservoir. While the seal must admit oil to the interior of the bearing, it also must prevent escape of oil spray and vapor from the interior of the bearing to the surrounding housing chamber.



Notches in metal washers permit oil to enter bearing while capillarity of felt prevents mist from leaving

Any oil spray or vapor which would otherwise escape through running clearances or through openings in the sealing washers is caught by the felt washer and retained by capillarity, settling slowly to the lower edge which is submerged in oil. In this way, the spray or vapor instead of escaping into the housing chamber and thence along the shaft into the motor, drains back into the reservoir.

More On Gear-Bore Proportions

To the Editor:

In commenting on Mr. Paul H. Black's stress investigations, Mr. P. N. Bland, writing in your September issue, considers factors other than those included by the former writer, but neglects still other factors which, in my opinion, sadly affect his argument and his figures.

First, Mr. Bland has concluded that, when a gear is forced on a shaft, the gear alone is strained, whereas not only does the gear expand, but the shaft contracts. That this is so should be obvious. In fact, it has actually been demonstrated by an experiment in which a tapered ring gage of normal proportions was forced along a tapered plug gage. The "before and after" measurements proved that the ring expanded about half as much as the difference in the diameters at the two positions. Seemingly, the plug had been strained about as much as the ring—an effect that would be expected of elastic forces in equilibrium, as they must be.

Second, the fact has been ignored that, although we speak of the stress as being concentrated at the weakest point, such is not literally the truth of the matter. The reason is that, no matter how uneven the sections, all the material is strained—the strain being almost proportional to the sectional area.

In Mr. Black's opinion, the thickness

of metal at the roots of the teeth is about one-half that at the keyway; but the length of all the tooth spaces at the roots combined is many times the length at the keyway. The total extension at these points will, therefore, exceed by many times the stretch at the keyway (5/16 in. wide), reducing the extension there.

Third, as the repair man well knows, shafts get smaller and bores get larger every time they are driven together. This is probably caused partly by molecular movement of the material endwise (surface material in particular), partly by a densening of the material under the effect of pressure, and partly by a sort of shearing action in which a little material is removed from the surface.

Fourth, some materials can stretch far beyond their elastic limit to a point where permanent set occurs without the slightest danger of rupture and without impoverishing the structure.

Fifth, the actual measured allowance (here 0.001 in.) is always greater than the mean interference or overlap between the dimensions since, because of natural roughness, the measuring instruments bridge the surface peaks. During driving, the peaks flow into the diminutive valleys and so reduce the nominal allowance.

After taking into account all the points mentioned, I think it is doubtful that the strain per in. in the width of the keyway would exceed 0.002 in. If so, the stress, instead of being 290,000 lb. per sq. in. as stated, would be but 58,000 lb. per sq. in., at which value some materials would still fracture.

—Francis W. Shaw
Whitworth, Lancs., England

Corrected Nomogram

To the Editor:

Among Mr. M. G. Van Voorhis' very interesting and useful papers on nomograms, in Fig. 15, page 101 of *Product Engineering* for March, 1936, there is an error: The diagonal a has been graduated from the wrong end; also the statement has been omitted that the moduli for r and s must be the same.

A more general statement of his equation for a Z-chart in order to have a proportionally graduated diagonal scale, is:

$$\frac{r}{s} = \frac{k-a}{a}$$

If m is the modulus for r and s, k a constant and K the length of the diagonal, then the equation of the diagonal scale a is:

$$Z = \frac{\dfrac{Km\ (k-a)}{a}}{\dfrac{m\ (k-a)}{a} + m}$$

This reduces to $Z = \dfrac{K\ (k-a)}{k}$

Therefore, the scale is proportional. The graduations of the a scale are also seen to be independent of the moduli of r and s. This fact may be of interest to your readers.

—C. P. Nachod
Louisville, Ky.

To the Editor:

Mr. Nachod is quite right about the diagonal a scale; it is reversed. The error could be corrected in another way; i.e., by reversing letters r and s on the vertical scales.

However, when Mr. Nachod develops a special case to cover nomograms with uniformly divided diagonal scales, it seems to me that he attaches more importance to this formula than was intended. In the discussion, I considered it merely as an interesting example of the general type of Z-chart constructed by the procedure outlined. It is true, though, as he states, that the r and s scales must be the same size if the diagonal scale is uniform.

In this connection, I think it is only fair to state that the paragraph concerning this chart was entirely rewritten during the course of editing. As a result, a somewhat different light was thrown on the example from that which was conveyed by the original wording. Still, it received my okay before publication and was also uncaught when my book was published. If there is a second printing of the latter, however, I will revise the paragraph and chart. I am glad to have Mr. Nachod call it to our attention.

—M. G. Van Voorhis
Bay Village, Ohio

Eliminating Separate Master File for Tracings

JOHN E. HYLER
Peoria, Illinois

When a large number of tracings are kept on hand and new ones must be continually made to introduce new designs and bring changes up to date, the manner of filing tracings is a matter of great importance. If numbers are issued to drawings as they are made and several different sizes of sheets must be used, the matter is complicated, for when someone calls for a drawing of a given number, the size is often not known. Because of this a master file is sometimes maintained and it is customary to go to this file first and find out the size of the drawing before asking for it in the blueprint department.

A method that avoids this loss of time, especially when drawings of separate parts on small sheets are kept, utilizes the file of smallest drawings as a master file in itself. For instance, individual parts are often drawn on 9x12 in. tracing paper sheets, and these sheets can be filed on edge in a drawer quite conveniently. In one place where the system is used, this size "catches" all individual parts and therefore includes possibly 75 per cent of all drawings. Then come 12x18, 18x24, 24x36, 36x36 in. sizes, and occasionally a larger drawing of indefinite size.

Whenever a drawing is made that is larger than 9x12 in., a 9x12 in. sheet is also given the number of the larger drawing and is filed consecutively in the 9x12 in. file. The only information contained on this sheet is the title or name of the larger drawing and its size.

Whenever a drawing is requested, the boy in the printing department goes to his 9x12 in. file. In most cases, he will find the drawing directly, but if it be a size other than 9x12, he will find the guide sheet which tells him the drawing size. That is equivalent to telling him in what file to look for it, for each size has a file of its own. This makes it possible to locate the drawings quickly in every instance.

[*Editor's Note*: In many engineering departments the size of the tracing is indicated by a prefix or suffix to the number. Thus, A-196 indicates an A size or 9x12 tracing. Or the letter may follow the number proper, as, 196A. Sometimes a prefixed number is used instead of a letter. The method suggested by the author may be of value where the drawing number does not indicate its size, in that it may save the work of maintaining a master file.]

More on Filing Magazine Clippings

To the Editor:

Mr. A. W. Eidman's contribution on keeping an index-less file for magazine clippings, which appeared under Question and Comment in your October issue, refers to a very perplexing problem in any engineering department.

However, the filing system suggested by him has the shortcomings typical of any alphabetical method. Take the case of "Prefinished Strip Steel." Any of the three words might be the one to use for alphabetical filing; so, if I use only one of them, I should have cross-references. Otherwise, I will be entirely out of luck if I do not think of the rather general title "Prefinished Strip Steel" when looking for something which I remember as "Lacquered," "Bonderized," "Parkerized," or "Plated" steel.

In our experience the only workable filing system which avoids the shortcomings of the alphabetical as well as the cross-reference type as much as possible is the standard one for building materials and appliances as issued by the American Institute of Architects, Document No. 172-B. Although this system is made up for architectural purposes, it can easily be extended to all kinds of engineering work. —H. W. SACHS

Agfa Ansco Corp.,

"Whetstones of Witte"

T. C. LLOYD

Robbins & Myers, Springfield, Ohio

Interest in puzzles requiring a fair amount of mathematical or analytical skill is a human trait known to be at least 4,000 years old. We refer now to the sort of puzzle typified by the one involving the Smith-Jones-Robinson trio and also by the one in which the pile of cocoanuts was divided by the castaways and the monkey—as published in recent issues of *Product Engineering* under the heading "Can You Work This One?"

When we say 4,000 years ago, our reference is to the Ahmes papyrus which was a sort of civil engineers' handbook to the ancient Egyptians. Besides telling how to compute the capacity of barns, giving rules for land surveying, and showing the solution of algebraic problems to the first degree, it contains this puzzle!

"Seven persons have each seven cats, each cat catches seven mice, each mouse eats seven stalks of barley, each stalk can yield seven measures in grain; what are the numbers and what is their sum?"

To us, this is not especially difficult. Yet it must be remembered that the Egyptians had no multiplication tables and, under such circumstances, it took a lot of pebbles to figure such a problem out. This particular problem, however, did not stay solved. More than 3,500 years later it again cropped up in England, only slightly modified, and through Mother Goose comes to us in this form:

"As I was going to St. Ives, I met a man with seven wives. Every wife had seven sacks, every sack had seven cats, every cat had seven kits. Kits, cats, sacks, and wives, how many were going to St. Ives?"

At that rate, in the year 5,500 our descendents will again be attempting to discover which of the Smith-Jones-Robinson trio was the engineer.

About 2,100 years ago Archimedes stayed up late one night working on this puzzle:

"The sun had a herd of bulls and cows, all of which were either white, gray, dun, or piebald. The number of piebald

bulls was less than the number of white bulls by $(\frac{1}{2} + 1/3)$ of the number of gray bulls. It was less than the number of gray bulls by $(\frac{1}{4} + 1/5)$ of the number of dun bulls. And it was less than the number of dun bulls by $(1/6 + 1/7)$ of the number of white bulls. The number of white cows was $(1/3 + \frac{1}{4})$ of the number of gray cattle (bulls and cows.) The number of gray cows was $(\frac{1}{4} + 1/5)$ of the number of dun cattle. The number of dun cows was $(1/5 + 1/6)$ of the number of piebald cattle. And the number of piebald cows was $(1/6 + 1/7)$ of the number of white cattle. How many were there of each variety?"

Then, 1,200 years ago, schoolmasters annoyed their students with a problem having six possible solutions. Here it is:

"If 100 bushels of corn are distributed among 100 people in such a manner that each man receives 3 bushels, each woman 2, and each child half a bushel, how many men, women and children are there?"

It is an unfortunate fact that our modern writers of mathematical books did not select some of their gayer predecessors to imitate. Arithmetic and algebra seem to have been taught in the guise of puzzles and the whole process dressed up as painlessly as possible. A good example of this is the text work on algebra written by Robert Records (1557) under the title "Whetstones of Witte". Incidentally, he was the first to use the equality sign, as we know it today, selecting it because "noe 2 thynges can be more equalle" than two parallel straight lines.

A prolific writer of such puzzles was Niccolo Fontana or Tartaglia (1500-1557). Modern psychologists have borrowed several of his problems for their intelligence tests. A typical example is this one which has occurred in many forms:

"A ship carrying as passengers 15 Turks and 15 Christians encountered a storm. In order to save the ship and crew, one-half of the passengers had to be thrown into the sea. Accordingly the passengers were placed in a circle and every ninth man, reckoning from a certain point, was to be cast overboard. It is desired to find an arrangement by which all the Christians can be saved."

This, it will be observed, has some of the characteristics of the cocoanut problem. And so it goes. One puzzle leads to another. Although perhaps slightly modified and clothed in a later style of dress, the succeeding ones still require essentially the same mental approach—all serving as "Whetstones of Witte."

Can You Work This One?

H. E. SMITH

Solution to Last Month's Problem—

Cow vs. Railroad

In order to solve this problem, let X = distance from the cow to the nearest end of the bridge, in ft. Since, by running toward nearest end, cow would have just made it and since train travels four times as fast as cow, the train was $4X$ from bridge when cow first saw it. Bridge is $2\ (X + 8$ ft.) long. In running toward farthest end, cow is hit after traveling $2\ (X + 8$ ft.) $- X - 12/3$ ft., or $X + 14\,1/3$ ft. To hit her, train must travel $4X + 2(X + 8$ ft.) $- 12/3$ ft. or $6X + 14\,1/3$ ft. Again, since train travels 4 times as fast as cow, $4 \times (X + 14\,1/3$ ft.) $= 6X + 14\,1/3$ ft. Solving, $X = 21\,1/2$ ft. Therefore, the distance to the center of the bridge is $29\frac{1}{2}$ ft. and the bridge is 59 ft. long.

This Month's Problem—

Watch Chain

Financially embarrased, a man with a 60-link gold watch chain approached a boarding house and offered to pay for his keep by giving up one link of the chain each night. The proposition was accepted. However, he hoped later to redeem his chain and therefore wanted to cut it as few times as possible. What was the best method for him to follow?

ACCELERATED and DECELERATED

When ordinary rotary cams cannot be conveniently applied, the mechanisms here presented, or adaptations of them, offer a variety of interesting possibilities for obtaining either acceleration or deceleration, or both

JOHN E. HYLER
Peoria, Ill.

FIG. 1—Slide block moves at constant rate of reciprocating travel and carries both a pin for mounting link *B* and a stud shaft on which the pinion is freely mounted. Pinion carries a crankpin for mounting link *D* and engages stationary rack, the pinion may make one complete revolution at each forward stroke of slide block and another in opposite direction on the return—or any portion of one revolution in any specific instance. Many variations can be obtained by making the connection of link *F* adjustable lengthwise along link that operates it, by making crankpin radially adjustable, or by making both adjustable.

FIG. 2—Drive rod, reciprocating at constant rate, rocks link *BC* about pivot on stationary block and, through effect of toggle, causes decelerative motion of driven link. As drive rod advances toward right, toggle is actuated by encountering abutment and the slotted link *BC* slides on its pivot while turning. This lengthens arm *B* and shortens arm *C* of link *BC*, with decelerative effect on driven link. Toggle is spring-returned on the return stroke and effect on driven link is then accelerative.

FIG. 3—Same direction of travel for both the drive rod and the driven link

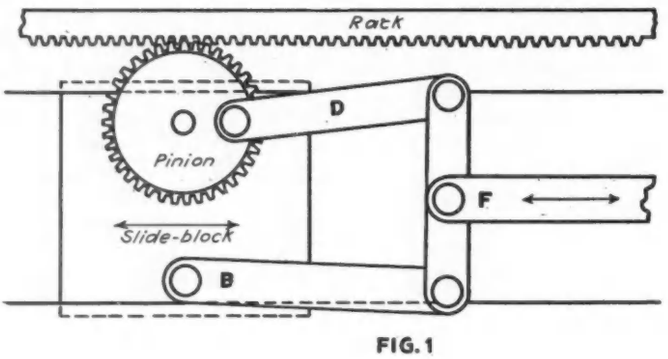


FIG. 1

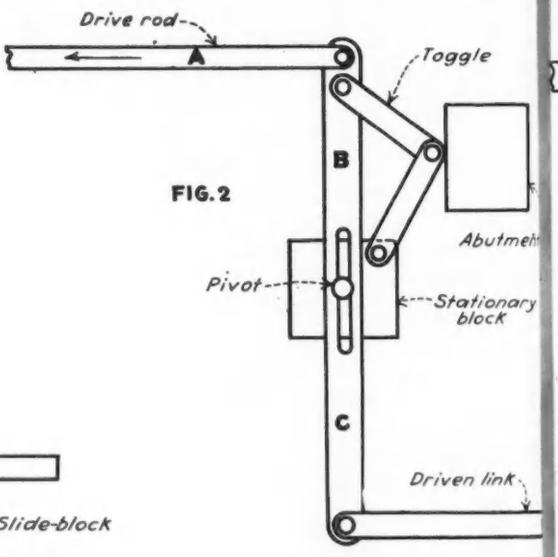


FIG. 2

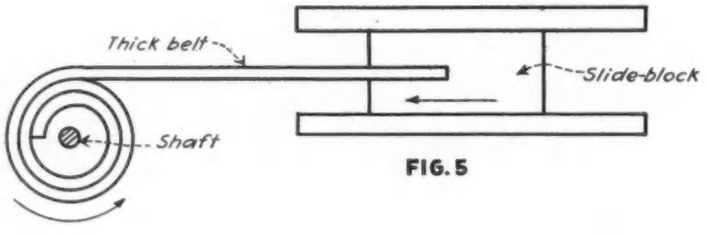


FIG. 5

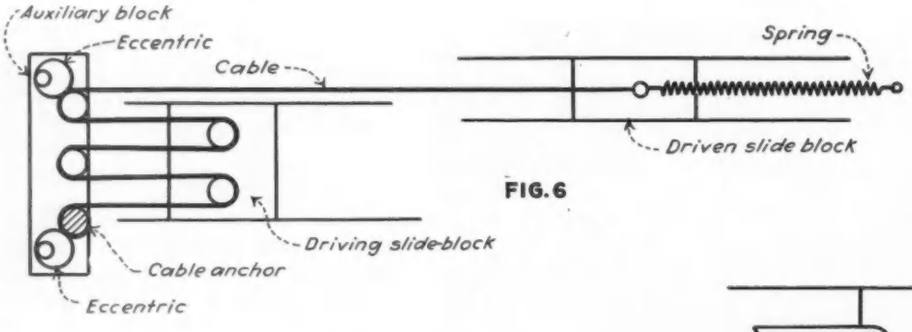


FIG. 6

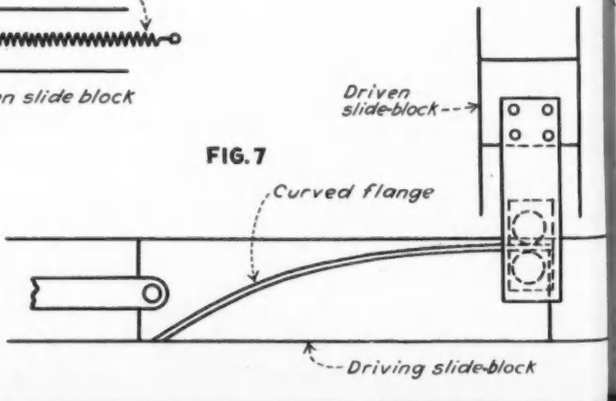


FIG. 7

LINEAR MOTION ELEMENTS

is provided by this variation of the preceding mechanism. Here, acceleration is in direction of arrows and deceleration occurs on return stroke. Accelerative effect becomes less as toggle flattens.

Fig. 4—Bellcrank motion is accelerated as rollers are spread apart by curved member on end of drive rod, thereby in turn accelerating motion of slide block. Driven elements must be spring-returned to close system.

Fig. 5—Constant-speed shaft winds up thick belt, or similar flexible member, and increase in effective radius causes accelerative motion of slide block. Must be spring- or weight-returned on reversal.

Fig. 6 — Auxiliary block, carrying sheaves for cable which runs between driving and driven slide blocks, is mounted on two synchronized eccentrics. Motion of driven block is equal to length of cable paid out over sheaves resulting from additive motions of the driving and the auxiliary blocks.

Fig. 7—Curved flange on driving slide block is straddled by rollers pivotally mounted in member connected to driven slide block. Flange can be curved to give desired acceleration or deceleration, and mechanism is self-returned.

Fig. 8—Stepped acceleration of the driven slide block is effected as each of the three reciprocating sheaves progressively engages the cable. When the third acceleration step is reached, the driven slide block moves six times faster than the drive rod.

Fig. 9—Form-turned nut, slotted to travel on rider, is propelled by reversing screw shaft, thus moving concave roller up and down to accelerate or decelerate slide block.

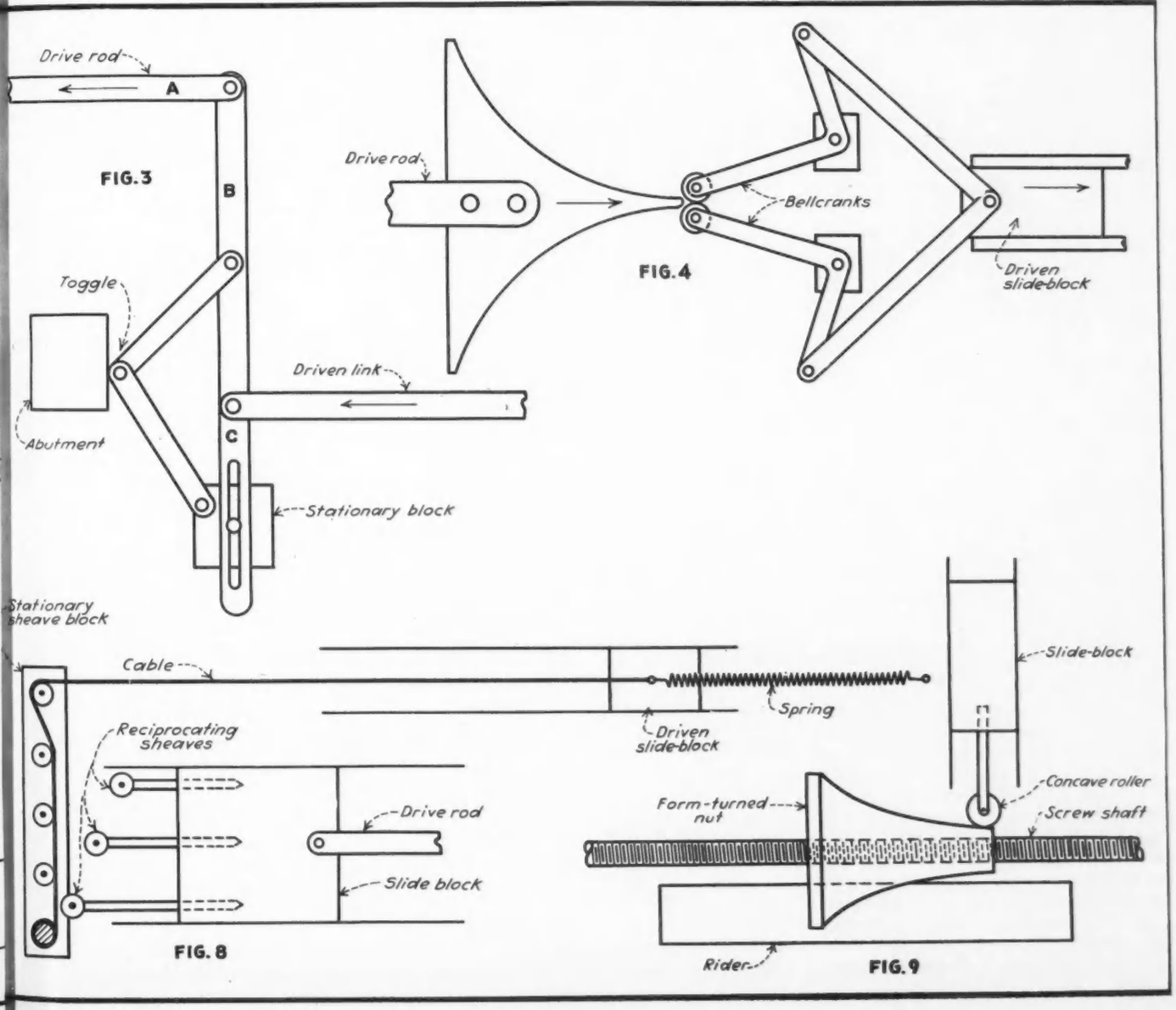


FIG. 3

FIG. 4

FIG. 8

FIG. 9

News

U.S. Steel Reports Progress in Research

WITH THE CLOSE of 1937, the United States Steel Corporation marks the tenth anniversay of the establishment of an intensive research program. Ten years ago Dr. John Johnston went to Kearny, N. J. from Yale University, to establish a central laboratory for the United States Steel Corporation which would deal with major problems affecting all products made by the corporation.

During the past decade, research and development work has been carried on in 174 laboratory departments throughout the corporation under the direct supervision of Rufus E. Zimmerman, vice-president in charge of metallurgy and research. The research organization is grouped into 89 divisions housed in 64 laboratory buildings.

During the past year the metallurgists of the United States Steel Corporation have given special study to creep deformation. As a result of their studies, they have concluded that reliable data cannot be obtained unless the specimens are subjected to creep tests for a period of at least 3,000 hr., using electric furnaces of special design and capable of maintaining throughout the specimen a temperature within plus or minus 1 deg. F. In interpreting the results of the tests the metallurgists have adopted the use of least squares, they having found that this method eliminates the personal error involved in graphical analysis.

Another investigation reported is the Brunorizing treatment for railroad rails. This is essentially a process wherein the steel rail is initially allowed to cool only to a few hundred degrees below its critical temperature, is then reheated to above its critical temperature and then allowed to cool completely. The process refines the grain structure of the metal as a result of which fatigue life is materially increased. It also practically eliminates the wearing down of the rail ends, known as "batter," caused by the hammering action of the wheels leaving one rail and impacting the next.

Austempering, a method of heat-treating which has been under investigation for a number of years, shows possibilities of imparting certain alloy steel properties to ordinary carbon steel, according to the research engineers of U. S. Steel. In this process the metal is cooled almost instantly from a point above its critical temperature to some lower level and held at substantially constant temperature, depending upon the final characteristics desired, in a bath of molten salt or lead for a predetermined period of time. This process gives results radically different from those obtained from the well-known quench and temper method. Extraordinary ductility even at relatively high hardness is developed.

Commercial Test Labs Form an Association

REPRESENTATIVES of twenty of the principal commercial laboratories of the country. at a meeting in Chicago last week, completed the organization of the American Council of Commercial Laboratories. One of the purposes of the council will be the promotion of the proper use of scientific testing methods for the protection and certification of quality in advertised goods.

In behalf of the council it is stated that the members have been and will be carefully selected to include only organizations to which product producers, retailers and consumers may look for unbiased determinations of quality. Engaging in research and testing for fees, these independent laboratories ascertain and report facts for clients and are uninfluenced by any ulterior consideration.

The following officers were elected to serve during 1938: president, Preston S. Millar, Electrical Testing Laboratories, New York, N. Y.; vice-president, Monroe L. Patzig, Patzig Testing Laboratories, Des Moines, Iowa; secretary, D. E. Douty, United States Testing Company, Hoboken, N. J.; treasurer, A. R. Ellis, Pittsburgh Testing Laboratory, Pittsburgh, Pa.

New Tests for Abrasion Resistance

ALTHOUGH developed originally for use with vitreous enamels, a new abrasion-resistance test developed at the Bureau of Standards by L. Shartsis and W. N. Harrison, may also be found useful on other materials having moderately smooth and glossy surfaces. It is considered that glazed ceramic ware, glass, plastics, paints, lacquers and similar material may use this test.

In the operation of this new test the powdered abrasive and small spherical weights are placed on the face of a flat specimen, being confined within a walled-in area. The entire assembly is then agitated in a horizontal plane by means of a commercial "screen shaker." Water is usually added to avoid the effect of variations in atmospheric humidity.

Wear resistance of the specimen is measured by the change in the specular gloss of the surface as determined by photoelectric means before and after the test. The percentage of the original specular gloss retained after the test is taken as the abrasion index. For example, abrasion index values obtained by this method have ranged from above 70 for a hard, acid-resisting sheet-iron enamel to less than 20 for a soft-lead, wet-process enamel for cast iron.

In conducting the tests it was found that feldspar was excellent as the abrasive agent for vitreous enamels. But in testing much harder or much softer materials the abrasive should probably be correspondingly harder or softer. For comparing different types of material with each other, the determination of the duration of the treatment or the number of strokes the samples must be shaken to produce a given effect is preferred, rather than basing the index on the loss of specular gloss in a given period of time or number of vibrations.

Standard Colors for Plumbing Fixtures

BECAUSE of the great emphasis that has been placed upon colors and color matching, manufacturers of kitchen and bathroom accessories found themselves involved in a multiplicity of stock, excessive returns and obsolesence of stock caused by changing trends in color tastes. To overcome this situation the industry through its committees and in cooperation with the National Bureau of Standards has adopted six standard colors for kitchen accessories and seven standard colors for bathroom accessories.

For kitchen accessories the standard colors adopted are white, kitchen green, ivory, delphinium blue, royal blue and red. The standard colors designated for bathroom accessories are white, bath green, orchid, ivory, maize, bath blue and royal blue. Standard color samples of these standard colors are held for reference at the National Bureau of

MEETINGS

SOCIETY OF AUTOMOTIVE ENGINEERS—*Annual meeting, Book Cadillac Hotel, Detroit, Mich., Jan. 10-14. John A. C. Warner, general manager and secretary, 29 West 39th St., New York, N. Y.*

AMERICAN ENGINEERING COUNCIL—*Annual meeting, Washington, D. C., Jan. 13-15. F. M. Feiker, secretary, 744 Jackson Place, Washington, D. C.*

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—*Annual winter convention, New York, N. Y., Jan. 24-28. H. H. Henline, national secretary, 33 West 39th St., New York, N. Y.*

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—*Annual meeting, Biltmore Hotel, New York, N. Y., Jan. 24-28. A. V. Hutchinson, secretary, 51 Madison Ave., New York, N. Y.*

EXPOSITIONS

NATIONAL MOTOR BOAT SHOW—*Grand Central Palace, New York, N. Y., Jan. 7-15.*

INTERNATIONAL HEATING AND VENTILATING EXPOSITION—*Grand Central Palace, New York, N. Y., Jan. 24-28. Chas. F. Roth, manager.*

NATIONAL AVIATION SHOW—*International Amphitheatre, Chicago, Ill., Jan. 28-Feb. 6. James Dunbar, Jr., manager.*

Standards. Duplicate samples are available at $10 per set for use during production to determine whether the colors comply with the standards. The industry also recommended that articles manufactured to match the standards should be identified by a sticker, tag or other label.

It is expected that producers and merchants as well as consumers will benefit as a result of new standards. Also it is to be expected that manufacturers of other home equipment used in the kitchen and bathroom will be interested in this development and will probably find it to their advantage to recognize the standard colors adopted.

Crane Company Forms Research Division

FORMATION of a division of engineering and research by the Crane Company of Chicago, with L. W. Wallace, formerly head of engineering research for the Association of American Railroads, as director, effective December 1, has been announced by Charles B. Nolte, president of Crane Company. The new Crane division will comprise the existing division of research and development and the product engineering department of the company.

"The new division has been formed to co-ordinate all engineering activities of the company," said Mr. Nolte, "and to further its progress in diversified fields. The importance and growth of this technical work have proved the advisability of maintaining a complete and well-staffed engineering division, free from all responsibilities except those relating to engineering research, design and experimental work."

Mr. Wallace, who will be directly responsible to Mr. Nolte, will direct the originating of new lines of products, the development of inventions and patents and the maintenance and improvement, if possible, of existing Crane products. The activities will include the operation of chemical, metallurgical, oil, steam, air, hydraulic, heating, plumbing and other research laboratories. The enlargement of the laboratories and the installation of new laboratory equipment are about completed, having been in progress for some time.

Mr. Wallace, a graduate of the Texas Agricultural and Mechanical College has been director of engineering research for the Association of American Railroads for the past three years. During this time he built up an engineering research organization which performed important work in the fields of air-conditioning of passenger cars, light-weight freight car construction, diesel-electric train operation and many phases of locomotive design and construction including a proposed steam-turbine, direct drive, condensing locomotive. As a consulting engineer, he has conducted extensive research for railroads.

New Research Started on Cylinder Head Design

AT A MEETING of six of the leading aluminum cylinder head manufacturers, a joint program of engineering and metallurgic research was formulated. This extensive program of laboratory work is to be undertaken on a cooperative basis by the leading aluminum cylinder head manufacturers including the Aluminum Company of America, Bohn Aluminum & Brass Corporation, Aluminum Industries, Inc., Advance Aluminum Castings Corporation, National Bronze & Aluminum Foundry Company and The Permold Company.

The metallurgical phase of this research program will investigate the problems connected with aluminum alloys used in cylinder heads with reference to the chemical and electrolytic reactions of cooling water for various sections of the country, will investigate the advantages of various types of gasket materials and seek other data concerning the circulating systems and agents.

Much of the laboratory work will be done at the laboratories of the Aluminum Company of American in Cleveland and the Bohn Aluminum & Brass Corporation in Detroit. Practically all tests will be duplicated in both of these laboratories.

In developing improved designs of cylinder heads, comparative data will be secured on different types of aluminum and iron cylinder head designs using fuels of definite octane ratings. One of the major phases of the research activity will be to attune the combustion characteristics obtained in various types of designs to the possibilities inherent in both present and future fuels. It is expected that with the proper design and materials, up-to-date automobile engines should produce better than 0.5 hp. per cu.in. of piston displacement.

Engineers Appraise Engineering Curricula

FOR THE FIRST time in the history of engineering education in the United States, engineering curricula throughout the country have been appraised by a representative body of engineers, and a single accredited list has been published of courses of study

Do You Know That—

LENSES made of an extraordinarily tough glass are not damaged by a sudden temperature difference of 450 deg. F. and will withstand severe impact loads. (66)

THE CORROSION rate of clean cast iron in a 3.5 per cent solution of sodium chloride may be increased by more than one-third by placing it in contact with an equal area of graphite coated cast iron. (67)

MORE THAN 100,000 lb. of copper wire of approximately the diameter of a human hair will be used this year by one company alone, the Warren Telechron Company, in the construction of coils for its synchronous electric clocks. In one piece, this wire would be 3,016,000,000 ft. long, enough to go around the world more than 23 times. (68)

deemed worthy of approval. The accrediting process has been carried out during the past two years by the Engineers' Council for Professional Development, a joint organization created by seven national engineering societies for the purpose of enhancing the status of the engineering profession. The participating groups are: American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers, The Society for the Promotion of Engineering Education, and National Council of State Boards of Engineering Examiners.

Working through four committees, the Council inaugurated a program dealing with the selection, guidance, training, and recognition of members of the engineering profession. The objective of the Committee on Engineering Schools was "to formulate criteria for colleges of engineering, which will insure to their graduates a sound educational background for practicing the engineering profession," and to give recognition to those institutions prepared to teach engineering according to these standards.

Announcement of the accredited list was made at the fifth annual meeting of E.C.P.D. on October 1, 1937. On that date 107 engineering schools had been visited and 445 curricula accredited in 16 branches of engineering. Committees of inspection throughout the country numbered 102 engineers. Mr. A. B. Parsons is secretary of the Engineers' Council for Professional Development with offices at 29 West 39th St., New York, N.Y. He will be pleased to furnish further information concerning E.C.P.D. and the accrediting program.

Case Histories in Patent Law

H. A. TOULMIN, JR.

(Editor's Note: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr., wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law.*)

CASE HISTORIES—NO. 4

QUESTION: Is it possible to maintain protection for a device for longer than the seventeen year term?

ANSWER: There are several ways by which patent control can be legally extended. There are others upon which courts frown.

Probably the best way to extend the monopoly is by constantly patenting new improvements. Experimental and design departments which are constantly working to improve the product are about the best assurance a manufacturer can have for the future prosperity of his business.

For instance, a basic patent on a taximeter was protected and, to all intents, extended by various improvement patents upon printing the tickets issued by the meter, upon devices which prevented the taxi-driver from defrauding the passenger, and upon various signal and safety devices.

I want to emphasize that to be effective in extending the patent monopoly the new patents must be upon something that the public wants and uses. The success of the plan is in direct proportion to the service that the manufacturer renders to the public through his designing and research. The new developments must be practical, not theoretical. Otherwise to take out new patents on them is a mere empty gesture.

TYPICAL CASE: A manufacturer of grease gun fittings for lubricating machinery tried to extend the monopoly which his basic patent afforded, by taking out a patent on substantially the same device. All he did was to substitute equivalent parts for some of the old parts. If there are five parts in a device and you try to substitute known mechanical equivalents for three of them, the patent is invalid, even though that particular combination has never been made before. The Supreme Court said in this case:

". . . The question then is whether, by this method, the patentee by improving one element of an old combination whose construction and operation are otherwise unchanged, may in effect, repatent the old combination by reclaiming it with the improved element substituted for the old element. That this cannot be done is shown by numerous cases in this and other Federal courts."

There is another way by which, in effect, a patent may be extended. If the appearance of the device is sufficiently distinctive so that during the seventeen years of the patent's life consumers identified the appearance with the manufacturer, then considerable good will would have been built up. If on the expiration of the patent, another should put out the same device—which he could legally do—but also closely imitated the appearance of the original device, the law on unfair competition would enable the original patentee to stop his competitor from deceiving customers.

Here are some useful things to remember in trying to keep patent protection alive:

A man who will go to great effort to circumvent a single broad patent will quickly become discouraged trying to get around a number of relatively minor patents. Therefore, it is well to constantly patent small improvements. It discourages infringement and, because of the varying dates of the improvements, extends the basic patent.

There are often many different ways in which a machine can be built. Protect them all from time to time, otherwise a competitor may come out with an improvement which he can patent and which will spoil your protection. Leading concerns in the radio, shoe-making and glass-forming industries have gathered large numbers of patents which are used under cross-licenses, and so, in effect, have prolonged the basic protection for many years beyond the life of the original patents.

The number of basic patents that have been issued is relatively small. Often the basic patent does not show a patent that is practical for commercial use. Therefore some improved patent of later date taking advantage of the disclosures of the basic patent is often the more profitable. That was true with the Wright and Curtiss patents on the airplane. Wright utilized the warping of the wings to prevent the plane from turning over. It was basically the right idea, but was not commercially practical.

Then Curtiss invented the ailerons which are door-like hinge members on the rear of the plane surface. They were practical and of great value commercially. Obviously if Wright, instead of Curtiss, had invented the ailerons at the time Curtiss did, he would to all intents and purposes have extended the basic patent for as many years as the Curtiss patent extended beyond the Wright patent.

This was accomplished in another way—by cross licensing under both patents under the control of the Aircraft Manufacturers' Association.

New Materials and Parts

Powered Variable-Speed Transmission

A cabinet type variable-speed transmission with electric motor attached. In the unit illustrated the output shaft runs at 90 r.p.m. at the slow speed and 4,300 r.p.m. at maximum speed, with speed adjustable to any figure between these limits. Standard V-belts running over adjustable molded plastic pulleys are employed. A handwheel on the cabinet controls a toggle lever through which speed is changed. A built-in dial indicates the output speed. Unit is available in a wide range of sizes and speed ratios and special designs for specific applications are obtainable. Speedmaster Co., 1301 Washington Avenue South, Minneapolis, Minn.

[The design of this variable-speed transmission as applied to the Continental DUALL contour sawing machine was described on pages 436 and 437 of the November number of *P.E.*]

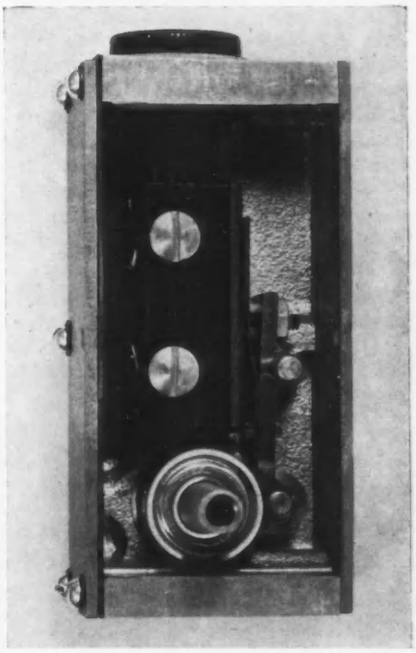
New Pigment

"Ti-Pure CR," a new titanium dioxide pigment for baked lacquers which will withstand high temperatures without yellowing. The pigment has sufficient color stability so that supplementary pigments are not required. It is claimed its color retention is superior to that of the regular grades of titanium dioxide in both air-dried and baked coatings and that it is equal, or superior, to the regular grades in rate of drying and retention. It also develops less discoloration in plastics. Available in two grades, one of medium oil absorption and the other of low oil absorption. Krebs Pigment & Color Corp., Subsidiary of E. I. du Pont de Nemours & Co., Wilmington, Del.

Pushbutton Control Station

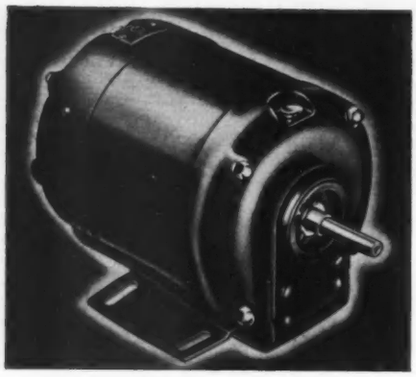
A new line of heavy-duty control stations of the surface and flush mounting types to supplant the existing line of heavy-duty pushbutton stations now manufactured by this company. The push-

button mechanism is of the unit type construction and can be mounted in combinations of one to ten buttons. The units have a set of normally open and a set of normally closed double break, silver alloy contacts. Two-way and three-way selector switches and pilot lights utilize the same base and are interchangeable with the pushbuttons. Surface mounting stations are black enamel finish, housed in a pressed steel box with multiple knockouts on top and bottom: Removing the front cover exposes front and sides to permit easy wiring. Flush mounting stations are available in combinations of one to five units with the frame adjustable so that the standard stations can be used on panels up to 1½ in. thick. For panels up to 3 in. an extra long shank can be supplied. Wiring may be from front or back. Maximum d.c. rating is 2.5 amp., 115 volts; 1.25 amp., 230 volts; 0.25 amp., 550 volts. Maximum a.c. rating is 10 amp., 110-550 volts. Allen-Bradley Co., 1311 S. First St., Milwaukee, Wis.



Super-Sensitive Line Voltage Switch

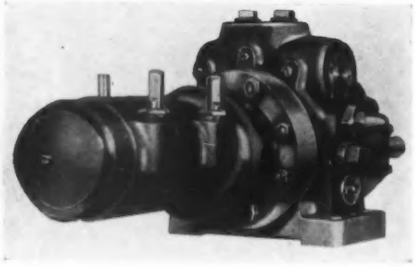
Available in five standard types: rotary, light contact, oscillating, plunger and push types. The main shaft controlling the operating mechanism in the rotary and light contact switches is substantially supported in sealed ball bearings. The internal operating levers in all models are equipped with an adjustable steel spring, insuring correct pressure on the contact button. Actual electrical contacts are made in a fully-inclosed Micro switch, designed for rapid contacts and continuous operation. Provisions have been made to wire for normally open or normally closed contacts. It is claimed the switches operate successfully at speeds of more than 200 contacts per minute. Applications are as limit switches, safety switches, or in connection with counting devices, circuit breakers, liquid level controls, gage devices, relays, pressure controls and governors. The National Acme Co., 170 East 131st St., Cleveland, Ohio.



Resilient Motor Mounting

In this new design of resilient mounted motor the cushioning rings are of ample size and of a material not affected by oil. It is claimed that they do not give way under the weight or power of the motor and do not deteriorate with age. The motor can be removed by loosening the end pieces and without disturbing the base. The Ohio Electric Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio.

Hydraulic Pump Units



A new line of hydraulic pump units with the control valves built into the pump housing. These compact units are made in two sizes, the larger being Model 10PWX and the smaller Model 5PWX. The larger unit, shown in the illustration, is a variable displacement piston pump which can be furnished with three different feed rates, fast, medium and slow, each of which is independently adjustable. In addition there is a constant volume pump which provides rapid traverse. Both pumps are driven by a single shaft. Sundstrand Machine Tool Co., Rockford, Ill.

All-Purpose Eraser

A new all-purpose mechanical eraser, known as the "Rush-Eraser," which is furnished with two types of refills. The Fiberglass eraser at one end will remove India ink from tracing cloth, erase ink or typewriting from hard surfaced papers and can be used as a superfine abrasive to polish metal, to sand tiny parts or retouch photographic negatives. The Rubberglass eraser at the other end is for erasing pencil or carbon copy and for use on thin or softer papers. The Eraser Co., Inc., 120-104 E. Washington St., Syracuse, N. Y.

New Insulating Cement

Requiring no reinforcement and capable of withstanding shocks and vibration, this new "Sonittep" castable insulation will stand temperatures up to 2,000 deg. F. It is suitable for casting light doors in heat-treating and annealing furnaces, for complete annealing furnace insulation, for forge furnaces, oil tanks, large pipe coverings and fittings, chemical plants, etc. It must be applied to a cold surface and allowed to stand for 72 hours before applying heat. This material is usually poured to a depth about three-quarters of the total thickness of the lining, and while the castable insulation is still damp "Sonittep" refractory is poured on top to complete the thickness of the lining. The entire mass dries and knits together, forming a Monolithic lining, which is dense and free from any joints. George F. Pettinos, Inc., 1206 Locust St., Philadelphia, Pa.

Prefinished Chrom Zinc Sheets

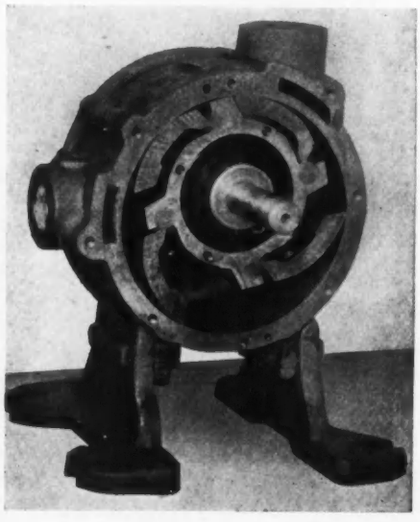
Zinc sheets prefinished with chromium plating in various designs for use in the manufacture of novelties, switch plates, kitchenware and similar applications. Obtainable in a variety of designs such as diagonal stripes, cross stripes and satin stripes and many others. Apollo Metal Works, 66th Place & S. Oak Park Ave., Chicago, Ill.

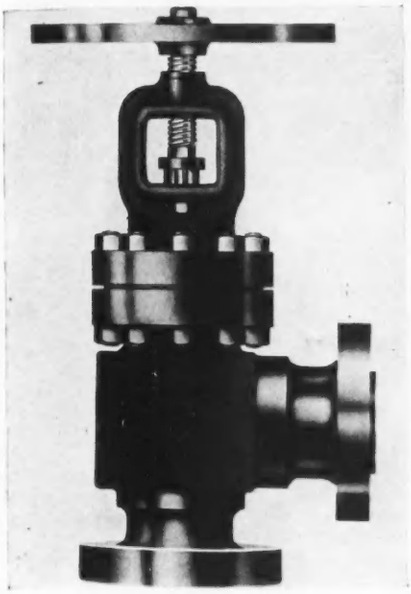
Temperature Gages

Of the modern dial-and-pointer type, claimed to be the first industrial application of a new "coils-within-coils" design for the bi-metal temperature-sensitive element. This all-metal temperature element is sheathed within a stainless steel stem. The circular dial case, 3-in. in diam., is mounted at right angles to and at the top of the stem. Accuracy is guaranteed to 1 per cent over the entire scale. Available in three models for use in checking operating temperatures in industrial applications such as heaters, dryers, baking ovens and small furnaces which have operating temperatures below 1,000 deg. F. The scale divisions of the circular dial are easy to read, the anodized aluminum dial face offers a distinct advantage since this type of scale is unaffected by the temperature to which the head may be subjected. A range of varying stem lengths are obtainable. Weston Electrical Instrument Corp., Newark, N. J.

Rotary Vacuum Pump

A full line of vacuum pumps for applications such as printing frames, bottle filling, vacuum chucks, paper folders and similar applications. Because of their construction the wings take up their own wear and wear in conformity with and are always in perfect contact with the cylinder walls. This results in maximum efficiency being maintained throughout the life of the unit. The small size of piston results in relatively much larger air chamber thus giving the pump exceptionally large capacity. Leiman Bros., Inc., 23 Walker St., New York, N. Y.



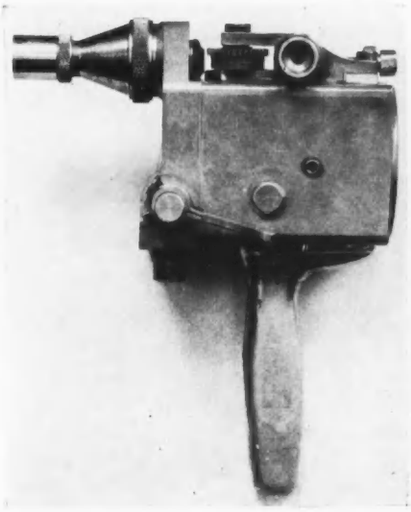


Forged Steel Stop Valves

A new line of stop valves for high-pressure service. Valves are made from a single block of forged steel in sizes from 2½ to 8 in., for pressures up to 2,500 lb. per sq. in. Furnished with flanged ends or with ends prepared for any type of welding. The valves are also made in both angle and offset types. Bodies, flanges and bonnets are hammer forged from chrome molybdenum steel, seats are Stellite faced, bolting is of class "C" A.S.T.M. steel, and the trim is of stainless steel. Clees Valve & Engineering Co., 90 West St., New York, N. Y.

Metal Spray Gun

It is claimed will deposit approximately 100 per cent more metal over a given time with approximately one-third less oxygen and acetylene consumptions per weight of metal deposited in larger size wires. In this "Majestic" MetaLayeR,



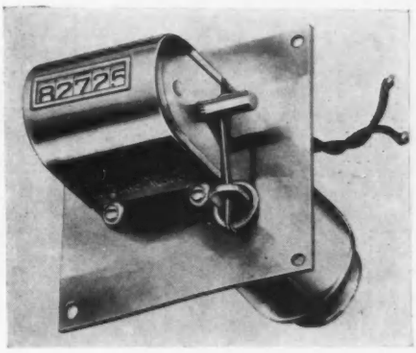
the train of gearing from the turbine to the final feed roll consists of two hardened worms, one bronze and one fiber gear of special composition. Entire gear assembly is inclosed in one compartment containing grease, insuring perfect lubrication. The gun can be lit and flames adjusted with or without the wire feeding, eliminating the waste of wire during adjustment. The final adjustment and control of oxygen, acetylene and compressed air are made with one movement of the valve handle. A standard handle for manual operation or adjustable tool post holder for mechanical operation can be supplied. Metals Coating Company of America, 495 N. Third St., Philadelphia, Pa.

Welding Electrodes

New coated electrodes especially adapted for a.c. current welding. Available in two grades of black and brown in sizes from 3/32 to 5/16 in., with a special 1/16 in. electrode for use with very low current values. All offer the advantages of arc stability, low spatter loss, high tensile strength and high ductility of deposit. The black electrodes are heavily coated so that the deposited metal is protected during its cooling period by a coating which is easily removed. They are especially suitable for down hand butt welding. The physical properties of the deposited weld metal are 45-50,000 lb. per sq. in. yield point; 60-70,000 lb. per sq. in. tensile strength; 25-35 per cent elongation in 2 in.; 40-60 per cent elongation free bend. The brown electrodes are flux covered, protecting the deposited metal by the combination of a gaseous arc shield and a light slag deposit which is readily removed with a hand hammer and wire brush. They are especially recommended for all general purpose work, horizontal, vertical and overhead welding. The physical properties of the weld metal are 58-65,000 lb. per sq. in. yield point; 70-75,000 lb. per sq. in. tensile strength; 20-25 per cent elongation; 28-35 per cent reduction of area and 20-30 per cent elongation by free bend. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Small Electric Counter

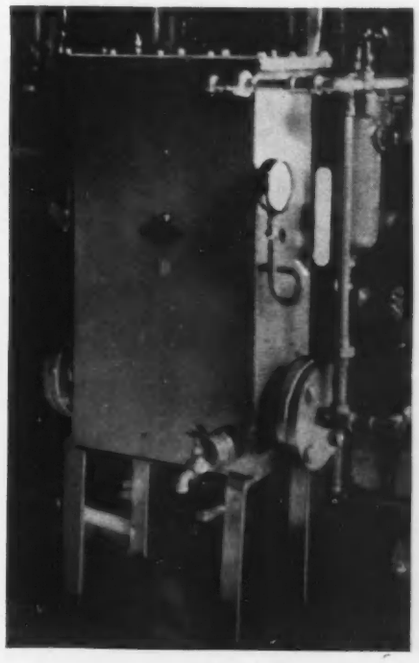
Adapted to economical built-in application on a wide range of coin-operated machines, production machinery and similar equipment. The counter is equipped with five large, legible number wheels with black figures on a white background, which give a capacity of 99,999. No spacing between the number wheels contributes to legibility. The counter is compact, measuring 1⅞ x 1½ x 1¾ in., and is mounted on a plate 2⅞



in. square. The operating relay is attached below the base plate and extends 1⅞ in. below the surface. The case inclosing the counter mechanism is of steel designed to afford full protection to working parts. Production Instrument Co., 1325 S. Wabash Ave., Chicago, Ill.

Oil Filters

Designed principally for the filtration of lubricating oil in diesel and gasoline engines and for fuel oil in diesel engines, this new type of filter employs fuller's earth as the filtering medium. The filter element is in the form of a hollow cylinder of compressed and molded fuller's earth, the oil filtering through the walls of the cylinder. Only a low pressure is required. It is claimed that this filter not only removes all insoluble matter but also neutralizes acids which cause sludges and erode metal surfaces. Filter unit consists of one or more filtering elements contained in a pressed steel housing. Available in four sizes. Briggs Clarifier Co., 3262 K Street, N. W., Washington D. C.

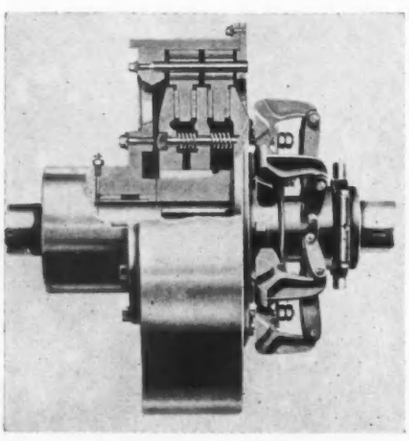


Photoelectric Counter

Known as the ratio differential control, this device is designed to make possible high-speed photoelectric counting. The maximum counting speed of photo-electrically operated direct driven counters ranges from 400 to 700 per min. The ratio differential control multiplies the speed of the direct driven counter by a factor of 2-4-8-16, etc., depending upon the desired ratio of counting to counter speed. The device furnishes one impulse to the final counter circuit for a definite number of interruptions of the light beam. The standard "scale-of-two" control supplied with a special Veeder-Root reset counter will count at a rate up to 5,000 per minute. United Cinephone Corp., 33rd St. at Queens Blvd., Long Island City, N. Y.

Friction Clutch

A new flexible clutch designed especially for use on oil, gas and diesel engine drives, or on drives where heavy impact is encountered on either end. The disks are driven by steel pins cushioned by rubber bushings. These bushings have special, self-lubricating bronze bushings on the inside of the rubber so that the disks slide freely on the steel pins. Rubber is cemented firmly into the friction disks. Single disk type clutch available in sizes from 4 to 10 in. bore and



in capacities ranging from 15 to 240 hp. at 100 r.p.m. Double disk type available in sizes from 3⅞ to 8⅜ in. bore and in capacities ranging from 30 to 240 hp. at 100 r.p.m. T. B. Wood's Sons Co., Chambersburg, Pa.

Caster Unit

A new low-pressure "Doenut" tired caster swivel fork. The tire is 10 in. high by 2¾ in. in diam., on a standard 4½ in. diam. cadmium-plated steel wheel of double disk type construction,

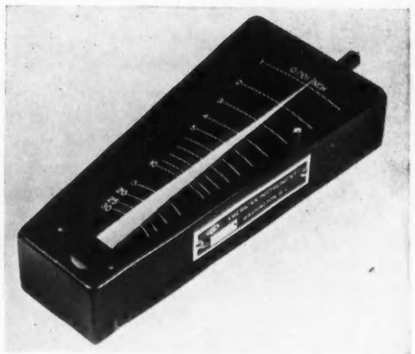
equipped with adjustable ball bearings. The fork is of heavy gage pressed steel with a swivel operating on a double ring ball bearing arrangement. It is furnished either with a flat plate or stud so it may be adapted to any type of unit. The flat plate model illustrated is 11¾ in. high. Load capacity of the caster unit of either type is 225 lb. per wheel. Musselman Products Co., 6308 St. Clair Ave., Cleveland, Ohio.

Monel With Ebony Finish

Known as "Ebonized" Monel for use where appearance must be maintained under temperatures up to 1,400 deg. F. The material is identical with standard Monel, except that a lustrous blue-black finish is imparted in a special oxidizing operation. It is claimed that tests by thermal experts have demonstrated that an improved efficiency is obtained with the use of this finish when used for reflectors and deflectors in electric heating units. The International Nickel Co., Inc., 67 Wall St., New York, N. Y.

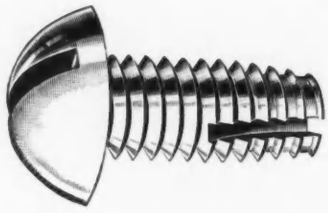
Vibrometer

For measuring the amplitude of vibration of structural or machine members. The needle point of the instrument is held against the vibrating part to be measured. The vibrating motion of the spindle is transmitted directly to the vibrometer pointer, which appears as bright yellow against a black background. The vibrating pointer appears double to the eye and the apparent intersection of the two images, read on the scale on the background, gives the amplitude of vibration directly in thousandths of an inch. Range of the instrument is from 0.001 to 0.030 in. amplitude. American Instrument Co., 8019 Georgia Ave., Silver Spring, Md.



Thread Cutting Screws

A new thread-cutting screw with standard machine screw thread that actually cuts its own thread in metals and plastics of practically any thickness. The thread-cutting slot, plus a special hardening process, eliminates the separate tapping operation normally required in the use of standard machine screws. It drives easily and quickly, without stripping, giving perfect thread contact the



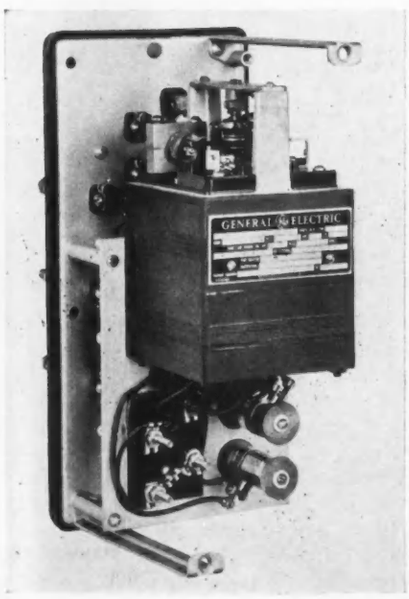
full depth of the hole. It is replaceable by an ordinary machine screw and can be removed without damage to the tapped hole or the screw itself. Shakeproof Lock Washer Co., 2501 N. Keeler Ave., Chicago, Ill.

New Valve Parts

A new handwheel design for Jenkins standard bronze valves affords exceptionally large gripping area without bulkiness and because of the deeply depressed center it will prevent the hand from touching the hot wheel nut. A new valve index plate held in the depressed center of the wheel gives the figure numbers of the valve and the disk number to aid in ordering replacements. A new renewable composition disk is also available for these valves. It is designated as disk No. 119-A and is claimed to have an exceptionally long life in steam service. Jenkins Bros., 80 White St., New York, N. Y.

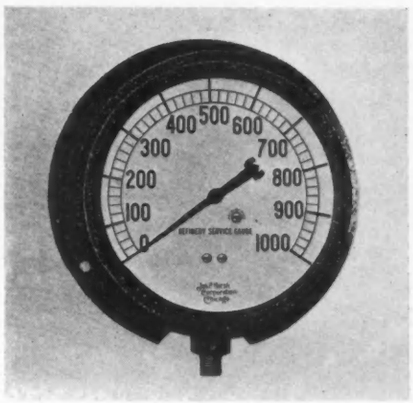
Relay with Voltage Restraint

A new polyphase power directional relay, Type CBP, with two "cup-type" torque-producing elements on one shaft. One element is a polyphase power directional element, and the other is a voltage restraint element, giving a directional relay which normally stays in the open position. When a fault occurs, the voltage restraint collapses, allowing the directional element full control. In addition to its use as a crude polyphase impedance relay it gives satisfactory "directional control" and can be used with instantaneous as well as delay overcurrent relays because it cannot close its tripping contacts on load current. Only the control voltage is on the contacts so there is no chance of not making contact because of low voltage or any other difficulty in short-circuiting overcurrent relay coils of low impedance. General Electric Co., Schenectady, N. Y.



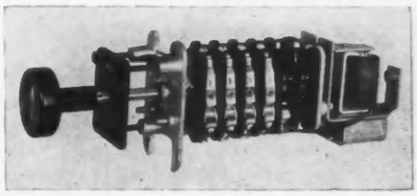
Bourdon-Tube Gage

For pressures below 100 lb. per sq. in., this redesigned line of gages uses a drawn steel bourdon tube and for pressures above 100 lb. per sq. in. the steel tube is lathe turned, being reamed to an accuracy of 0.0005 in. A special design of joint employing lathe threads and a special socket and cone is used and is claimed by the manufacturer to withstand pressures and temperatures far beyond those encountered in service. Stainless steel and Monel metal are used throughout in the movement. A special design of zero adjustment known as the "Recalibrator" was developed which is claimed to correct for any distortion of the tube. Correction is made by inserting a screwdriver in a readily accessible screw and turning until the pointer indicates the correct pressure. The cases for both styles of gages are claimed to be moisture, vapor, dust and rust proof. Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.



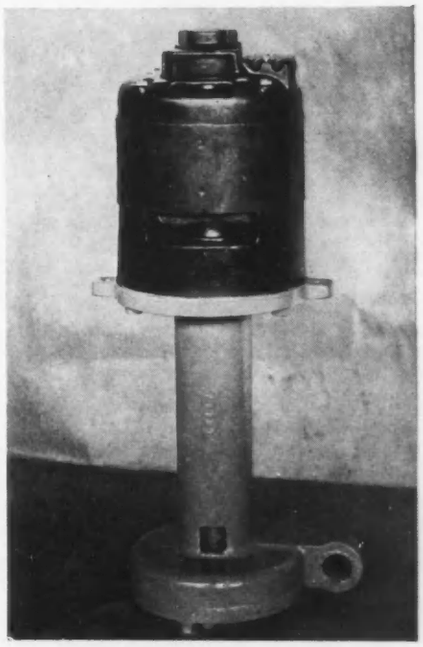
Auxiliary Relays

Type HEA, a new high-speed, hand-reset, multi-contact auxiliary relay for switchboard mounting. Available in two models, the HEA-11A, having 6-circuit contacts and the HEA-11B, having 10-circuit contacts. Operating within 20 milliseconds ($1\frac{1}{4}$ cycles), this relay is particularly applicable where a number of operations are to be performed simultaneously. Among the functions which may be performed simultaneously by the use of this relay are: tripping the main circuit breaker of the circuit, tripping an auxiliary breaker, opening a neutral breaker, sounding an alarm, and operating other relays which in turn perform various functions. General Electric Co., Schenectady, N. Y.



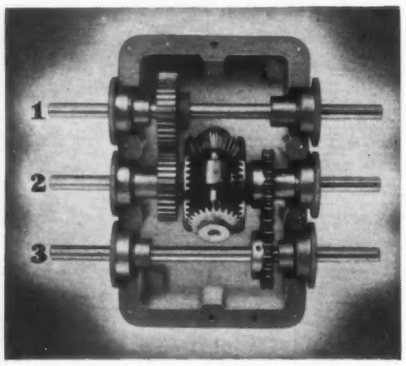
Centrifugal Coolant Pump

A small, compact, vertical, submerged type centrifugal pump, built only in the $\frac{3}{4}$ in. size and designed especially for the circulation of coolant, cutting compounds, or similar liquids containing abrasives in suspension. Impeller is mounted directly on extra large diameter extended motor shaft, eliminating necessity of any lower pump bearing. Pump casing is cast integral with motor support at the top of which motor is held in position with male and female lock to insure permanent alignment. Impeller is of open, double-suction type, hydraulically balanced to eliminate end thrust. Clearances between impeller and casing are sufficient to remove possibility of binding from chips. Available in capacities up to 30 gal. per min. with heads up to 19 ft. Motor is $\frac{1}{4}$ hp., 1,750 r.p.m. Goulds Pump Inc., Senaca Falls, N. Y.



Variable-Speed Controller

A new unit of accessory equipment for use with the Reeves variable-speed transmission. It is known as the model MDB-3 and its principle of operation is similar to that of the differential in an automobile rear end. Referring to the accompanying illustration, shafts 1 and 3 are connected to the driven machines or machine elements, the speeds of which are to be synchronized. Shaft 2 is connected to the speed changing screw of the Reeves transmission. When shafts 1 and 3 are driven in the same direction at the same speed shaft 2 remains stationary. Any difference in the speeds of shafts 1 and 3 causes shaft 2 to rotate and thereby change the setting of the transmission until synchronous speed has



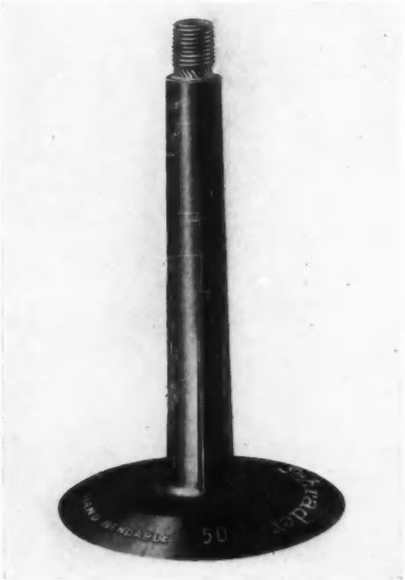
been restored. This controller may also be used with other equipment to control index or register, either manually or with photoelectric devices. Overall dimensions of the unit are 8 in. wide, 11 in. long and 6⅝ in. high, the shafts extending on both sides in order that installation may be made as desired. Reeves Pulley Co., Columbus, Ind.

Two-Stage Built-Together Pump

Designed especially for operating at high speeds against heads up to 475 ft. Consists essentially of a two-stage centrifugal pump, with inclosed bronze impellers, mounted directly on the shaft of a Fairbanks-Morse splash-proof motor. Two rugged motor ball bearings take all of the radial and unbalanced thrust loads, and require greasing only once or twice a year. The pumps are suited for all classes of general pumping service where the liquid is free from excessive foreign matter and is of a low viscosity. Compactness of design makes the pump especially advantageous where space is limited. It requires no special foundation and can be mounted in a horizontal, vertical or angular position. Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

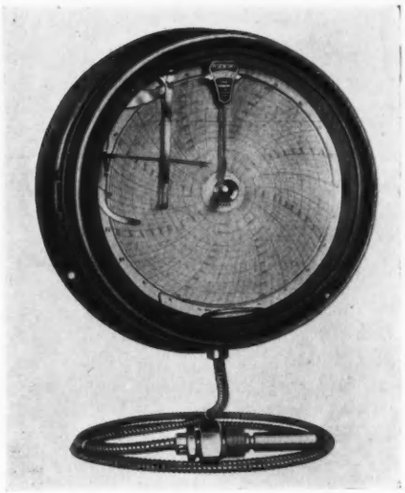
Hand Bendable Valve

A hand bendable rubber covered valve which may be single bent to any desired angle to fit wire, disk wheels, etc. Valve insert is of special metal tubing that will assure correct hand bending and will not close the air passage. The base of the valve is prepared for vulcanization to the tube and it may be bent before or after it has been applied to the tube. A. Schrader's Son, 470 Vanderbilt Ave., Brooklyn, N. Y.



Galvanized Sheet Steel

A sheet steel with a heavy coating of commercially-pure zinc applied by a special process so that the zinc will not crack or peel even when subjected to relatively severe drawing or forming operations. This new material known as "Zincgrip" is produced in both sheets and coils and carries from 50 to 75 per cent more protective zinc than sheets generally used for fabricated products. Available in sheets ranging from 16 to 28 gage. It is claimed that this material can withstand a heavier draw than has ever before been accomplished with galvanized sheets. The American Rolling Mill Co., Middletown, Ohio.

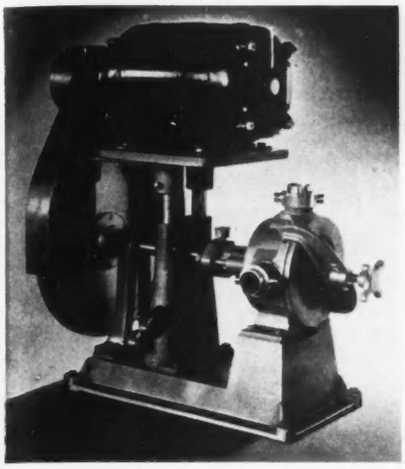


Improved Thermometers

A new line of indicating and recording thermometers known as Mono-therm thermometers wherein the entire system is either welded or brazed to eliminate any possibility of leaky joints and thereby assure a tight thermal system. Available as vapor-pressure, gas-filled and liquid-filled types, either indicating or recording. Other improvements include protection against overrange, a wider Bourdon spring and a larger and stronger movement. The Foxboro Co., Foxboro, Mass.

New Type Steel Valve

Known as the "Duravalve," developed for high pressure and high temperature service (1,500 lb. at 950 deg. F.). Internal Stellite seats are claimed to end valve maintenance due to steam leaking between the valve seat ring and the valve body. The valves are made in one basic size and then tapped, or bored for welding, for ½, ¾ or 1 in. pipe. Hancock Valve Div., Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

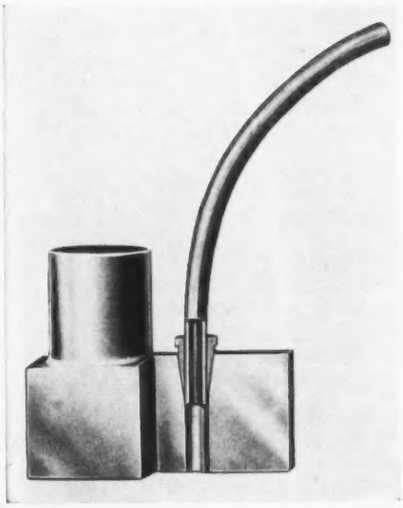


Variable-Speed Rotary Pump

Designed for applications where positive and accurate capacity changes are desired. By turning a small handwheel located near the base of the unit, the driving motor is either raised or lowered, thereby increasing or decreasing the effective pitch of the V-belt motor pulley which is of the variable pitch type. With standard 1,800 r.p.m. motor the speed may be adjusted within a range from 200 to 500 r.p.m., changing the pump capacity correspondingly. The adjustments can be made while motor is running. The unit is available with two different sizes of pumps, one requiring a 1 hp. motor and the other a 2 hp. motor. The unit illustrated is designed especially for applications in creameries and food plant factories and is available in both standard and sanitary models. Viking Pump Co., Milwaukee, Wis.

Drive Bushing Connection

A new type of tubing joint for lubrication feed lines to bearings where space is limited and there is insufficient room for threaded nuts or conventional bushings. The small tapered brass bushing in these connectors has a center hole to slide readily over the tubing and is then driven into a shallow tapered hole, the taper fit causing the bushing to grip tightly both the tubing and the walls of the tapered hole. Available in sizes for tubing as small as 3/32 in. O. D., for which size the diameter of the drive bushing collar is only 3/16 in. Bijur Lubricating Corp., Long Island City, N. Y.



Proportioning Control

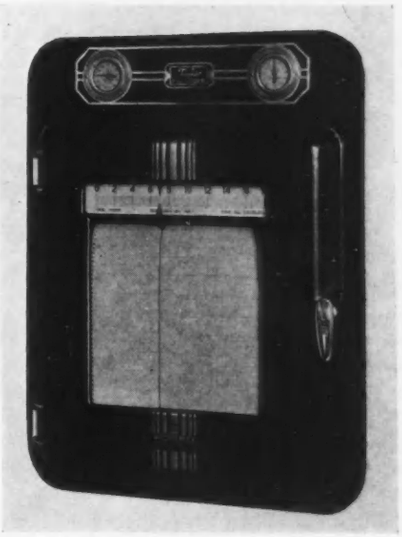
Designed to control fuel fired or electrically heated units which cannot be successfully controlled by the simple 2-position or 3-position type of controller. The Wheelco proportioning "Capacitrol" consists of an electrical device mounted integral with an indicating pyrometer and operating in conjunction with simple valving or contacting equipment. It achieves the effect of a continuous input variation by varying the ratio of "on-time" to "off-time" in a predetermined time cycle sufficiently small so that the change in temperature during one time cycle is practically negligible. It thereby provides unform temperatures regardless of varying heat requirements and overcomes time lag resulting from slow reaction of furnace temperatures. Wheelco Instruments Co., 1933 S. Halsted St., Chicago, Ill.

New Dielectric Enamel

A new black enamel, with special dielectric properties, especially suitable for finishing electrical apparatus, such as steel switchboards and instrument panels, coils, etc. It dries to a rubber finish and is tough, durable and has high electrical resistance. It is applied by spraying. A surfacer, with similar dielectric properties, is also supplied for preparing the surface to be finished with the enamel. Maas and Waldstein, Newark, N. J.

Potentiometer Controller

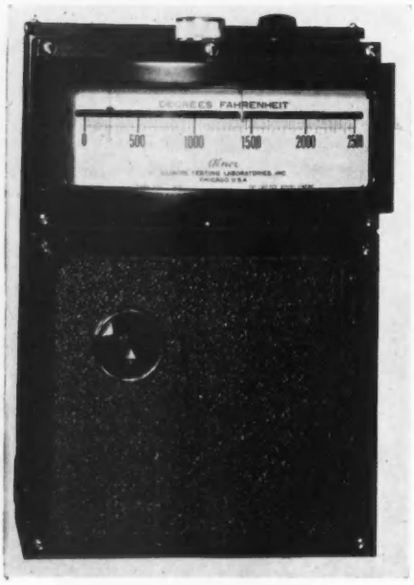
For applications where smooth, proportional valve action is imperative and the potentiometer principle of temperature measurement is preferred. Called the Fulscope Micromax controller, this instrument utilizes the same completely adjustable, air-operated control mechanism as used in previous Fulscope models and the temperature measuring system is the Micromax recording and indicating potentiometer. All functions are fully automatic including automatic reference-junction compensation, positive balancing of the potentiometer circuit, and current standardization. This Fulscope control unit operates in conjunction with the Taylor Motosteel diaphragm



valve which can be supplemented with the Taylor Valv-Precisor or Dubl-Response control unit where precision valve action and compensation for changes in load may be necessary. Taylor Instrument Companies, Rochester, N. Y.

Hard Cutting Alloy

A new hard cutting tool and wear resisting alloy trademarked "Tantaloy." It is a general purpose hard metal used as a tip which is brazed to a steel shank to form a cutting tool and also used for wear-resisting surfaces. Its unusual toughness makes Tantaloy tipped tools highly efficient for severe service. Tantaloy tipped tools are available in all standard lathe, boring mill and turret tool sizes. The metal is also available in tips which may be brazed to boring bars, counter bores, or special tools and is recommended for gages, lathe centers, centerless grinder rests, wearing surfaces and the general field of application of abrasion and corrosion-resisting metal. Fansteel Metallurgical Corp., North Chicago, Ill.



Pyrometer Controller

For the automatic control of temperatures in heat-treating furnaces, melting pots and similar equipment, these "Alnor" controllers operate electrically. Pointer of the indicating pyrometer carries a small vane. An adjustable target carries two condensor plates which serve as the capacitive element of a tuned circuit. When the temperature indicating pointer and the target concide a circuit change is produced which operates a relay. The relay controls the electric switch in electrically heated equipment or controls the fuel valve in the case of fuel fired operation. A red bull's eye indicates whether the heat supply to the furnace is on or off. The pyrometer indicator of this controller is the Type 2860, available for indicating a wide range of temperatures from 0 to 3,000 deg. F. Illinois Testing Laboratories, Inc., 420 N. LaSalle St., Chicago, Ill.

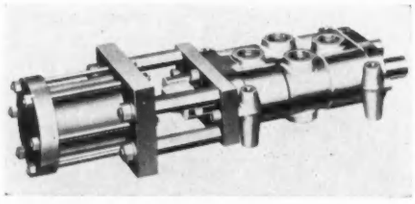
Precision Resistors

Called Riteohm "71", these vitreous enameled precision resistors of 1 watt rating, are claimed to be accurate within 1 per cent. They are especially designed for use as voltmeter multipliers, in laboratory equipment, radio and electrical test sets and similar applications. Advantages are permanent protection against moisture and atmospheric corrosion. Construction consists of a single layer of special alloy wire wound on a ceramic tube with the ends of the wire mechanically locked and brazed to the copper lugs. The resistor is then covered with a special vitreous enamel. Because of their small size, $1\frac{1}{4}$x$\frac{3}{8}$ in. for 50,000 ohms and 7/16x2 in. for 100,000 ohms, and because of the single layer construction and relatively few turns, these resistors have low inductance and distributed capacity. Ohmite Mfg. Co., 4846 W. Flournoy St., Chicago, Ill.

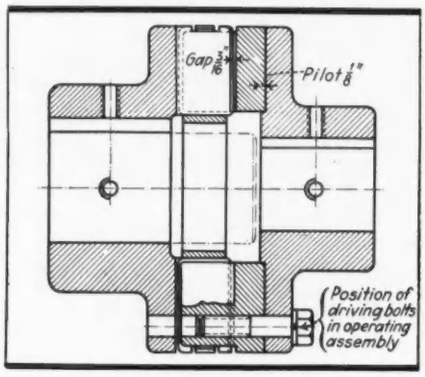
New Enamel Frit

A new frit that has high reflectance, workability, a wide firing range and was developed as a super-opaque frit for one coat enamel. Designated as No. 2117, it can be used without blending with other enamels. Reported tests indicate the highest tear resistance and highest opacity. Reflectance is 76.5 per cent at 65 grams with 7 per cent clay and no opacifier. Addition of 4 per cent tin oxide increases reflectance $2\frac{1}{2}$ per cent. Fired at a comparatively low temperature, this frit reduces warpage to a minimum. Porcelain Enamel & Mfg. Co., Baltimore, Md.

Pilot Operated Hydraulic Valve



Designed for installations requiring remote or automatic control and available as a 4-way unit for the control of double-acting cylinders and as a 3-way unit for single-acting cylinders. The valve has two positions only and is actuated by an air cylinder. Remote or automatic control requires the use of a 4-way pilot valve which controls the air cylinder. The pilot valve may be hand lever operated, foot lever operated, double solenoid unit or a diaphragm operated unit. The pilot operated hydraulic valves are fully balanced remaining in any given position without air on the pilot cylinder. Speed of opening and closing can be regulated by a needle valve in the pilot exhaust line. These pilot operated hydraulic valves have a bronze forged body suitable for oil, water or corrosive liquids up to 200 deg. F. and are designed and tested to withstand any reasonable shock above their working pressure classification. Made in ½, ¾ and 1 in. sizes and two styles, one for 1,000 lb. per sq. in. working pressure and the other for 2,000 lb. per sq. in. working pressure. C. B. Hunt & Son's Co., Salem, Ohio.



Flexible Coupling

New line of flexible couplings known as L-R Type WQ for light or heavy service. An important feature of this new coupling is that disconnection can be made without moving the load cushions or steel retaining band, it being only necessary to take out the capscrews and reverse them so they operate from the body. Three types of cushions are used—Metalflex which is a high-grade brake lining material used where heavy shock loads are encountered; leather load cushions of oak-tanned belting leather for use on sustained loads and greater misalignment; and a rubber duck fabric vulcanized under pressure, which cushion is employed where loads fluctuate considerably and maximum resiliency is important. The cushions are free floating between the metal jaws, the internal end resting on the hub, and are retained in place by a steel band. Thus the cushions are free to move and adjust themselves to any momentary position of the jaws. For readjustment the cushions can be lifted out and interchanged without tearing down the coupling. Available in standard sizes with bores from 1½ to 14 in. for ratings from 2 to 2,000 hp. at 100 r.p.m. Lovejoy Flexible Coupling Co., 5019 W. Lake St., Chicago, Ill.

Stainless Steel Plug Valve

This new design features a plug and seat ring made of stainless steel and possessing a Brinell hardness in excess of 500. It is recommended for severe service such as continuous throttling for pressure reduction or free blow-off duty. It is claimed that this new plug and seat almost entirely eliminates danger of wire drawing and cutting. Jenkins Bros., 80 White St., New York, N. Y.

Manufacturers' Publications

BEARINGS—The Bantam Bearings Corp., South Bend, Ind. Engineering Bulletin 101. Complete list of available sizes and types of ball thrust bearings in sizes from ½ to 3½ in. bore, and roller thrust bearings in sizes from 6 to 12 in. O.D.

BEARINGS—New Departure, Division General Motors Corp., Bristol, Conn. Booklet D, 20 pages, 5½x8½ in. The principles involved in the New Departure self-sealed bearings are presented in the booklet "Sealed," together with illustrations of typical successful applications and a brief review of the accomplishments of the bearing.

BERYLLIUM COPPER—The Riverside Metal Co., Riverside, N. J. Booklet, 28 pages, 8⅝ x 11¼ in. Covering the composition of beryllium copper, forms in which it is available, typical applications, data on fabrication and heat-treatment, and tables of properties and the physical constants of this alloy. Curves are also given to show the relation of time and temperature of the precipitation hardening treatment to tensile strength, electrical conductivity and elongation.

CHAIN DRIVES—Baldwin-Duckworth Chain Corp., Springfield, Mass. Dossier A-3, 14 pages, 9½x11 in. Covering the solution of a power transmission problem for hammer mills.

CLEANING METAL SURFACES—Hilo Varnish Corp., 42-60 Stewart Ave., Brooklyn, N. Y. Folder, 6 pages, 5x7½ in. Presenting different types of cleaning methods, both mechanical and chemical. Mechanical methods described include sand blasting, tumbling, rolling and burnishing. Chemical methods described include solvent washing, acid cleaning and alkali cleaning, including electrolytic cleaning with alkali solutions.

CLUTCHES—T. B. Wood's Sons Co., Chambersburg, Pa. Bulletin 380, 4 pages, 8½x11 in. Special features and specifications of their new flexible friction clutch are covered.

CONVEYOR CHAIN—Link-Belt Co., 220 S. Belmont Ave., Indianapolis, Ind. Folder No. 1651, 6 pages, 8½x11 in. Describing their No. 4250 swivel chain, which will operate around 12 in. radius horizontal curves.

CUT GEARS—D. O. James Mfg. Co., 1120 W. Monroe St., Chicago, Ill. Catalog 144A, 8½x11 in. Data covering all types of gears including cut spur gears, molded plastic gears and pinions, cut bevel and mitre gears, worms and worm gears, spiral gears, internal gears, etc. A section is devoted to general engineering data.

DUREX BEARINGS—Moraine Products Div., General Motors Corp., Dayton, Ohio. Handbook, 40 pages 6¼x9 in. Covering the structure and properties of Durex bearings, their applications, installation and available sizes.

EXPANDED METALS—Milcor Steel Co., Milwaukee, Wis. Folder, six pages, 8½x11 in. Describing the outstanding features of Milcor expanded metal. Six samples of different styles are mounted on the pages and one page is devoted to typical constructions using expanded metal for purposes such as machinery guards, open partitions, grilles, electric heater grids, truck body screens, ventilator screens and similar applications.

FRACTIONAL HORSEPOWER MOTORS — The Dumore Co., Racine, Wis. Convenient pocket folder containing bulletins on the various types of fractional horsepower universal motors and giving mounting dimensions, the motor horsepower ranging from 1/600 to ¼. Types include direct drive and worm gear reducers. The folders provide a convenient means for filing future issues of the bulletins.

FASTENINGS—Shakeproof Lock Washer Co., 2501 N. Keeler Ave., Chicago, Ill. Catalog 34, 25 pages, 5x8 in. Detailed information on their line of lock washers, in addition to descriptive data on the new Shakeproof thread-cutting screw.

GEAR PUMP—W. F. and John Barnes Co., Rockford, Ill. Pamphlet, 6 pages, 8½x11 in. Information and descriptive illustrations covering the outstanding features of the Barnes gear pump.

GEARS—Philadelphia Gear Works, G St. & Erie Ave., Philadelphia, Pa. Catalog, 72 pages, 8½x11 in. Complete technical data and specification tables on the Philadelphia line of gears. Also includes data on couplings and speed reducing units.

"HEAT"—Johns-Manville, 22 E. 40th St., New York, N. Y. Booklet, 48 pages, 6x9 in. An interesting booklet on the control of heat. It covers the history of heat from ancient times, the discovery of what heat is, the science of heat conservation, modern materials available for conserving heat, and illustrations of the specific use of these materials in individual industries.

"MACHINING ALUMINUM"—Aluminum Company of America, Pittsburgh, Pa. Booklet, 32 pages, 5½x8½ in. A revised edition of their booklet containing detailed data on the machining of aluminum and its alloys.

MOLYBDENUM IN CAST IRON—Climax Molybdenum Co., 500 Fifth Ave., New York, N. Y. Looseleaf binder, 9½ x 11½ in. 55 pages. This booklet is divided into five sections devoted to: (1) general information relating to definitions and standards; (2) covering the effects of additions of molybdenum to cast irons; (3) alloys combining molybdenum with chromium or nickel in gray iron; (4) gray iron applications; and (5) a general index.

MOTORS—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio. Bulletin Sheets Nos. 122 and 124. Describing the Reliance splash-proof and explosion-proof a.c. Type AA squirrel-cage motors.

NICKEL ALLOY STEEL—The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Bulletin U-3, 16 pages, 8½x11 in. Covering the application of nickel alloy steels for hand tools. A number of charts showing mechanical properties of heat-treated nickel alloy steels are included.

NICKEL SILVER ALLOYS—The Riverside Metal Co., Riverside, N. J. Booklet, 48 pages, 8⅝ x 11¼ in. Describing the history and properties of nickel silver, the forms in which it is available, together with numerous examples of its application. A short history of the company and a list of products manufactured, and the laboratory service which it is equipped to render, is given.

PRODUCTION CONTROL INSTRUMENTS—The National Acme Co., 125 E. 131st St., Cleveland, Ohio. Bulletin No. 3707, 18 pages, 8½x11 in. Describing three new models of Chronolog, production control instruments, giving complete information on use and operation. A new line of super-sensitive line voltage switches and Namco solenoids are also described.

STAINLESS STEEL—Ludlum Steel Co., Watervliet, N. Y. A factual data book entitled "The Working of Silcrome Stainless Steel" presenting detailed instructions on methods of fabricating Ludlum stainless with information as to the grades of tool steel best suited to each operation.

STEEL CASTINGS—Vanadium Corporation of America, 420 Lexington Ave., New York, N. Y. Bulletin, 24 pages, 8½x10¾ in. Describing properties and applications of various vanadium alloy steels for castings where high strength is required without excessive weight or high cost. Also includes complete specifications and photographs of various types of high strength castings.

THERMOMETERS—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y. Catalog 1125B, 24 pages, 8½x11 in. Conveniently arranged listings of the complete line of TAG industrial thermometers covering details of construction and illustrating various forms and connections for different applications. Also includes miscellaneous metal and woodback thermometers, hygrometers, U-gages, mercurial vacuum gages and mercurial barometers.

TUBING—Timken Steel & Tube Div., The Timken Roller Bearing Co., Canton, Ohio. Handbook, 40 pages, 4½x7 in. Data and tables covering the dimensional tolerances and physical properties of Timken seamless mechanical tubing. Conversion tables and a summary of standard definitions of terms used in specifying tubing are also included.

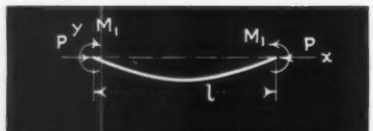
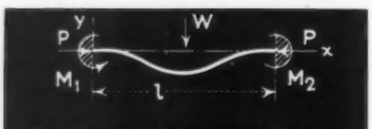
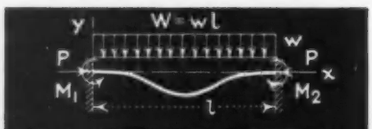
WELDERS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Catalog Section 26-320, 4 pages, 8½x11 in. Describing the features, construction and application of the Midget Marvel Flexarc welder. Specifications and operating costs are included together with a list of questions and answers covering its use and operation.

PRODUCT ENGINEERING + REFERENCE BOOK SHEET

Beams Under Simultaneous Transverse and Axial Loading

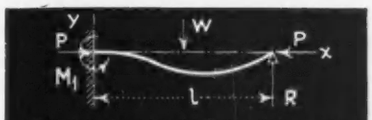
RAYMOND J. ROARK
Professor of Mechanism, University of Wisconsin

(Continued from page 520, December 1937 issue)

	LOADING AND SUPPORT	MAXIMUM BENDING MOMENT, MAXIMUM DEFLECTION, END SLOPE, AND CONSTRAINING MOMENT
6	Beam on end supports under axial compression and triangularly distributed transverse load	Moment from $x = 0$ to $x = l$: $M = wj^2\left[\frac{\sin\frac{x}{j}}{\sin u} - \frac{x}{l}\right]$ Max M at $x = j$ arc cos $\left(\frac{\sin u}{u}\right)$ Deflection equation $x = 0$ to $x = l$: $y = -\frac{w}{P}\left[\frac{x^3}{6l} + \frac{j^2\sin\frac{x}{j}}{\sin u} - \frac{jx}{u} - \frac{1}{6}lx\right]$ $\theta = -\frac{w}{P}\left(\frac{j}{\sin u} - \frac{j}{u} - \frac{1}{6}l\right)$ at $x = 0$ $\quad \theta = \frac{w}{P}\left(\frac{-j}{\tan u} + \frac{j}{u} - \frac{1}{3}l\right)$ at $x = l$
7	 Beam under axial compression and equal and opposite end couples	Max $M = M_1 \sec\frac{1}{2}u$ at $x = \frac{1}{2}l$ $\quad \theta = -\frac{M_1}{P}\tan\frac{1}{2}u$ at $x = 0$ Max $y = -\frac{M_1}{P}\left[\frac{1-\cos\frac{1}{2}u}{\cos\frac{1}{2}u}\right]$ at $x = \frac{1}{2}l$
8	Beam on end supports under axial compression and unequal end couples	Moment equation $x = 0$ to $x = l$: $M = \left(\frac{M_2 - M_1\cos u}{\sin u}\right)\sin\frac{x}{j} + M_1\cos\frac{x}{j}$ Max M at $x = j$ arc tan $\left(\frac{M_2 - M_1\cos u}{M_1\sin u}\right)$ Deflection equation $x=0$ to $x=l$: $y = \frac{1}{P}\left[M_1 + (M_2 - M_1)\frac{x}{l} - (M_2 - M_1\cos u)\frac{\sin\frac{x}{j}}{\sin u} - M_1\cos\frac{x}{j}\right]$ $\theta = \frac{1}{P}\left[\frac{M_2 - M_1}{l} - \frac{M_2 - M_1\cos u}{j\sin u}\cos u + \frac{M_1}{j}\sin u\right]$ at $x = l$ $\quad \theta = \frac{1}{P}\left[\frac{M_2 - M_1}{l} - \frac{M_2 - M_1\cos u}{j\sin u}\right]$ at $x = 0$
9	 Beam with fixed ends; axial compression and transverse center load	$M_1 = M_2 = \frac{1}{2}Wj\left[\frac{1-\cos\frac{1}{2}u}{\sin\frac{1}{2}u}\right]$ $\quad$ Max $y = -\frac{Wj}{2P}\left[\tan\frac{1}{2}u - \frac{1}{2}u - \frac{(1-\cos\frac{1}{2}u)^2}{\sin\frac{1}{2}u\cos\frac{1}{2}u}\right]$ At $x = \frac{l}{2}$ $\quad M = \frac{1}{2}Wj\left[\tan\frac{1}{2}u - \frac{1-\cos\frac{1}{2}u}{\sin\frac{1}{2}u\cos\frac{1}{2}u}\right]$
10	 Beam with fixed ends; axial compression and uniform transverse load	$M_1 = M_2 = wj^2\left[1 - \frac{\frac{1}{2}u}{\tan\frac{1}{2}u}\right]$ $\quad$ At $x = \frac{l}{2}$ $\quad M = wj^2\left[\frac{\frac{1}{2}u}{\sin\frac{1}{2}u} - 1\right]$ Max $y = -\frac{wj^2}{P}\left\{\left[1 - \frac{\frac{1}{2}u}{\tan\frac{1}{2}u}\right]\left[\frac{1-\cos\frac{1}{2}u}{\cos\frac{1}{2}u}\right] + \sec\frac{1}{2}u - \frac{1}{8}u^2 - 1\right\}$

LOADING AND SUPPORT	MAXIMUM BENDING MOMENT, MAXIMUM DEFLECTION, END SLOPE, AND CONSTRAINING MOMENT

11



Beam with one end fixed, other end supported, under axial compression and transverse center load

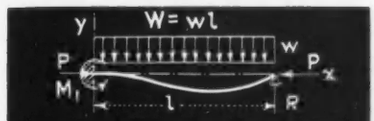
$$\text{Max } M = M_1 = \frac{W l}{2}\left[\frac{j \tan u \,(\sec \frac{1}{2} u - 1)}{j \tan u - l}\right] \qquad R = \frac{1}{2} W - \frac{M_1}{l}$$

Moment equation:

$$x = \frac{l}{2} \text{ to } x = l, \quad M = M_1\left[\frac{\sin \frac{x}{j}}{\tan u} - \cos \frac{x}{j}\right] + Wj\left[\sin \frac{1}{2} u \cos \frac{x}{j} - \frac{\sin \frac{1}{2} u \sin \frac{x}{j}}{\tan u}\right]$$

Deflection equation $x = \frac{l}{2}$ to $x = l$: $y = -\frac{1}{P}\left\{ M_1\left[1 - \frac{x}{l} + \frac{\sin \frac{x}{j}}{\tan u} - \cos \frac{x}{j}\right] - Wj\left[\frac{l - x}{2j} + \frac{\sin \frac{1}{2} u \sin \frac{x}{j}}{\tan u} - \sin \frac{1}{2} u \cos \frac{x}{j}\right]\right\}$

12



Beam with one end fixed, other end supported, under axial compression and uniform transverse load

$$\text{Max } M = M_1 = w l j\left[\frac{\tan u \,(\tan \frac{1}{2} u - \frac{1}{2} u)}{\tan u - u}\right] \qquad R = \frac{1}{2} w l - \frac{M_1}{l}$$

Moment equation $x = 0$ to $x = l$:

$$M = M_1\left(\cot u \sin \frac{x}{j} - \cos \frac{x}{j}\right) + w j^2\left[\frac{\sin \frac{x}{j}}{\sin u}(1 - \cos u) + \cos \frac{x}{j} - 1\right]$$

Deflection equation $x = 0$ to $x = l$: $y = -\frac{1}{P}\left[M_1\left(1 - \frac{x}{l} + \cot u \sin \frac{x}{j} - \cos \frac{x}{j}\right) - w j^2\left(\cot u \sin \frac{x}{j} - \frac{\sin \frac{x}{j}}{\sin u} - \cos \frac{x}{j} + \frac{l x - x^2}{2 j^2} + 1\right)\right]$

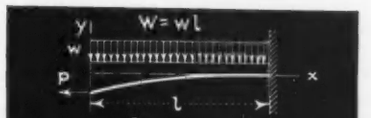
13

Same as Case (1), cantilever with end load, except that P is tension

$$\text{Max } M = -W j \tanh u \quad \text{at } x = l$$

$$\text{Max } y = -\frac{W}{P}(l - j \tanh u) \quad \text{at } x = 0$$

14



Same as Case (2), cantilever with uniform load, except that P is tension

$$\text{Max } M = -w j\,[l \tanh u - j\,(1 - \text{sech } u)] \quad \text{at } x = l$$

$$\text{Max } y = -\frac{w j}{P}\left[j\left(1 - \frac{1}{2} u^2 - \text{sech } u\right) - l\left(\tanh u - u\right)\right] \quad \text{at } x = 0$$

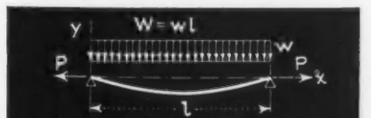
15

Same as Case (3), end supports, center load, except that P is tension

$$\text{Max } M = \frac{1}{2} W j \tanh \frac{1}{2} u \quad \text{at } x = \frac{1}{2} l$$

$$\text{Max } y = -\frac{W}{P}\left(\frac{1}{4} l - \frac{1}{2} j \tanh \frac{1}{2} u\right) \quad \text{at } x = \frac{1}{2} l$$

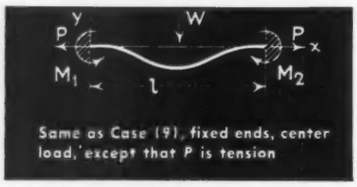
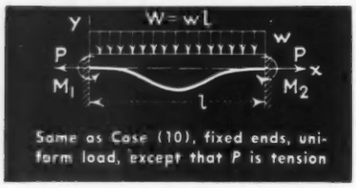
16



Same as Case (4), end supports, uniform load, except that P is tension

$$\text{Max } M = w j^2\left(1 - \text{sech } \frac{1}{2} u\right)$$

$$\text{Max } y = -\frac{w}{P}\left[\frac{1}{8} l^2 - j^2\,(1 - \text{sech } \frac{1}{2} u)\right]$$

LOADING AND SUPPORT	MAXIMUM BENDING MOMENT, MAXIMUM DEFLECTION, END SLOPE, AND CONSTRAINING MOMENT
17  Same as Case (9), fixed ends, center load, except that P is tension	$M_1 = M_2 = \frac{1}{2} W j \left[\frac{\cosh \frac{1}{2}u - 1}{\sinh \frac{1}{2}u} \right]$; Max $y = -\frac{W j}{2P} \left[\frac{1}{2}u - \tanh \frac{1}{2}u - \frac{(1-\cosh \frac{1}{2}u)^2}{\sinh \frac{1}{2}u \cosh \frac{1}{2}u} \right]$ Max $+M = \frac{1}{2} W j \left[\frac{1-\cosh \frac{1}{2}u}{\sinh \frac{1}{2}u \cosh \frac{1}{2}u} + \tanh \frac{1}{2}u \right]$ at $x = \frac{1}{2}l$
18  Same as Case (10), fixed ends, uniform load, except that P is tension	$M_1 = M_2 = w j^2 \left[\frac{\frac{1}{2}u - \tanh \frac{1}{2}u}{\tanh \frac{1}{2}u} \right]$; Max $+M = w j^2 \left[1 - \frac{\frac{1}{2}u}{\sinh \frac{1}{2}u} \right]$ at $x = \frac{1}{2}l$ Max $y = -\frac{w j^2}{8P} \left[\frac{4u(1-\cosh \frac{1}{2}u)}{\sinh \frac{1}{2}u} + u^2 \right]$ at $x = \frac{1}{2}l$

Illustrative Example

The following example will serve to show the effect of axial loading on moment and deflection and to make clear the use of the formulas.

A 4-in., 7.7-lb. I-beam 20 ft. long is supported at the ends and carries a load of 50 lb. per ft. (including its own weight) and is under an axial compression of 3,000 lb. It is required to determine the maximum deflection, the maximum bending moment, and the maximum fiber stress.

Here $P = 3{,}000$, $l = 240$, $I = 6$, $I/c = 3$, $E = 30{,}000{,}000$, $A = 2.21$, $w = 50/12 = 4.17$, $W = 20 \times 50 = 1{,}000$, $j = \sqrt{EI/P} = 245$, $u = l/j = 0.98$. The problem will be solved in three ways, as discussed in December.

Deflection Ignored:

$$M = (1/8)(Wl) = 1/8\ (1{,}000)\ (240) = 30{,}000 \text{ in. lb.}$$

$$y = -\frac{5}{384} \times \frac{Wl^3}{EI} = -\frac{5}{384} \times \frac{(1{,}000)\ (240^3)}{(30{,}000{,}000)\ (6)} = -1.0 \text{ in.}$$

$$S = \frac{P}{A} + \frac{M}{I/c} = \frac{3{,}000}{2.21} + \frac{30{,}000}{3} = 11{,}350 \text{ lb. per sq. in.}$$

Here S is the compression in the top fibers at the center.

Johnson's Formula:

$$M' = \frac{M}{1 - a\,Pl^2/EI} = \frac{30{,}000}{1 - \frac{5}{48}\frac{(3{,}000)\ (240^2)}{(30{,}000{,}000)\ (6)}} = \frac{30{,}000}{1 - 0.10} = 33{,}300 \text{ in. lb.}$$

$$S = \frac{3{,}000}{2.21} + \frac{33{,}300}{3} = 12{,}450 \text{ lb. per sq. in.}$$

Precise Formula:

$$M' = w j^2 (\sec \tfrac{1}{2}u - 1) = 4.17\ (245^2)\ (1.1334 - 1) = 33{,}250 \text{ in. lb.}$$

$$u = -\frac{w j^2}{P} (\sec \tfrac{1}{2}u - 1 - \tfrac{1}{8}u^2) = -\frac{(4.17)\ (245^2)}{3{,}000}\left[1.1334 - 1 - \tfrac{1}{8}(0.98^2)\right] = -1.107 \text{ in.}$$

$$S = \frac{3{,}000}{2.21} + \frac{33{,}250}{3} = 12{,}430 \text{ lb. per sq. in.}$$

For this beam, the critical Euler load $P_{cr} = \pi^2 EI/l^2 = 30{,}800$. Hence P is 0.1 P_{cr}, and it may be noted that the error in the first solution is 10 per cent, while Johnson's formula gives practically the same M' as the precise formula.

If P is tension instead of compression, the maximum moment and deflection are same as calculated by first method.

By Johnson's formula, the maximum moment is:

$$M' = \frac{30{,}000}{1 + 0.10} = 27{,}260 \text{ in. lb.}$$

By the precise formula, the maximum moment and the deflection are as follows:

$$M' = w j^2 (1 - \operatorname{sech} \tfrac{1}{2}u) = (4.17)\ (60{,}000)\ (1 - 0.8913) = 27{,}200 \text{ in. lb.}$$

$$y = -\frac{w}{P}\left[j^2 (1 - \operatorname{sech} \tfrac{1}{2}u - \tfrac{1}{8}l^2 \right] = -\frac{4.17}{30{,}000}\left[245^2\ (1 - 0.8913) - \frac{1}{8}(240^2) \right] = -0.943 \text{ in.}$$

For this case, $S = (3{,}000/2.21) + (27{,}200/3) = 10{,}420$ lb. per sq. in. tension in bottom fibers at center.

In this example, it should be noted, the calculations have been carried out to more significant figures than either the exactness of the data or the accuracy of the formulas would ordinarily warrant, the extra significant figures being taken merely for illustrative purposes.